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CONTENTS

		Page
J. H. Gisborne	*Agricultural Experimental Records, Northern Nigeria* ..	241
H. Hirst and A. Agrotis	*The Development of the Poultry Industry in Cyprus* ..	251
G. W. Ivens	*The Effects of Arboricides on East African Trees and Shrubs—I. Acacia Species*	257
T. A. Jones and G. K. Maliphant	*High Yields in Cacao Field Experiments and their Significance in Future Cacao Research*	272
A. Müntzing	*Disease Resistance in Field Trials with Cacao at Hacienda Clementina, Ecuador*	276
H. W. S. Allison and T. A. Rohan	*A New Approach to the Fermentation of West African Amelonado Cocoa*	279
T. J. Lansbury	*The Composition and Digestibility of Some Conserved Fodder Crops for Dry Season Feeding in Ghana—IA. Rice Straw*	289
W. M. Graham and S. Kockum	*Protection of Bagged Maize with Lindane and DDT*	292
T. W. Kirkpatrick and N. W. Simmonds	*Bamboo Borers and the Moon*	299
Review	Ensete *Cultivation in the Southern Highlands of Ethiopia*	302
Book Reviews		308
Recent Publications		322

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Vol. XXVI. No. 103 CONTENTS July, 1958

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Agricultural Experimental Records, Northern Nigeria

J. H. Gisborne

Secretary for Research and Specialist Services, Ministry of Agriculture, Northern Nigeria

In his notes on a visit made to Northern Nigeria between 20 October and 10 November 1957, Mr G. W. Nye, C.M.G., O.B.E., Agricultural Adviser to the Colonial Office, commented:

> ' The system of recording experiments adopted by the agronomy section is the most efficient I have seen anywhere in colonial territories. It would be doing a service to other Departments of Agriculture if those concerned would produce a paper giving details of the methods used. '

It is the purpose of the present paper to try to meet this request.

From 1923 (when formal agricultural experimental work started in Nigeria) until 1931, the Nigerian Agricultural Department published an *Annual Bulletin* in which the results of each year's experiments were recorded. Publication was suspended as an economy measure during the slump of the early 1930s, and had not been restarted at the beginning of the Second World War, when experimental work virtually came to a standstill. In 1943, Mr W. E. Freeman (then Botanist for Northern Nigeria) found that as a result of wartime disorganization, it was extremely difficult to obtain any records of experiments, other than those of the Botany section and those recorded in the *Bulletins*. He went to considerable trouble to extract from old files in stations all over the Region such data as he could find, and filed these by stations in a loose-leaf filing system. The result was extremely meagre, consisting often of a mere statement of the treatments and the yields. It was the determination that such a situation should not be allowed to occur again that led Mr Freeman and the present writer to develop the main details of the system of recording which is now maintained. It is not proposed to describe the development of the system chronologically, but to present it as it now stands.

THE FARM GARDEN

New introductions are first assessed as ' possibles ' in any area in small observation plots. It is only at a later stage that the more promising ones are placed in formal variety trials. At this observation stage, where the new introduction stands to be condemned and discarded after a year or two on its performance, it is clearly desirable that better-than-normal conditions should prevail, so that the crop is given every chance of success. These observation plots are therefore normally placed in a fenced ' Farm Garden ' where they can receive close attention. Details from a page from the foolscap-size record book designed for Farm Garden use are illustrated in *Figure 1*. These books contain one hundred numbered sheets, and are printed on the right-hand page only, so that the blank left-hand page is available for additional notes. The books are bound in stout cardboard.

PLOT RECORD BOOK

1. CROP

ARACHIS HYPOGEA	GROUNDNUTS	SAMARU 57	L 121
Botanical name	English name	Variety	Bot. No.

2. ORIGIN

Selected from Riyom material	1947	CB 82 P 14
Obtained from	Date	File reference

3. POTENTIAL USES — Export of kernels for oil and local consumption of kernels

4. CULTIVATION DETAILS

5	$\frac{1}{40}$ acre	½ cwt Superphosphate on 12/6 by placement
Plot No.	Area	Manuring (rate, type, date, method)

Harrow 20/5 ridge 25/5 reridge 14/8	at stake	2	9″ × 2½′
Preparation and after cultivation (nature and dates)	Planting method (broadcast, etc.)	Plants per stand	Spacing

5. DATES 1958

27/5	—	—	8/6	—	15/7	18/10	18/10
Sowing	Transpl.	Thinning	1st supply	2nd supply	Flowering	Tops harvest	Grain, tubers, etc., harvests

6. % STAND

89	—	96	92
Before 1st supply	Before 2nd supply	After final supply	At harvest

7. YIELDS (lbs)

In shell	49·5	haulms	38	1520
On head (in shell, etc.)	per plot	Green tops, hay, etc.	per plot	per acre

Kernels	62	30·5	1220	1315
Dry grain, kernels, tubers, etc.	Thresh %	per plot	per acre	per acre full stand

8. OBSERVATIONS AND COMMENTS (Particular mention to be made of any apparent cause for poor performance at any stage, pests and diseases, etc. Section (*e*) is particularly important and should always be completed).

(*a*) Germination and establishment.

Very good

(*b*) Subsequent growth.

Very good

(*c*) Seed setting, etc.

Excellent

(*d*) Pests and diseases.

No Rosette—Leaf spotting at end of season

(*e*) Considered comment on performance to date and prospects of this crop.

This variety with a good yield of both tops and kernels shows promise

(*f*) Other notes.

A long season upright variety typically two seeds per pod with large even sized kernels

Figure 1. Contents of typical page from a Farm Garden record book

Each plot is given a page in the record book: thus, if a given introduction is being tried in combination with three or four different manurial or cultivation treatments, each treatment is given a separate page.

For headings 1 to 7 the data are written into printed ' boxes ', with the nature of the information in each ' box ' printed underneath. It is found that this gives a completed form from which the main data are readily picked out. Headings 1, 2, 4, 5 and 6 require no comment: heading 3 (' Potential uses ') may appear unnecessary, but it is surprising how often the original purpose of an introduction is overlooked after a few years, particularly if there have been a series of staff changes. For example an Amaranthus introduced as a possible small-grain crop was assessed on its spinach potential, because a species of Amaranthus is commonly used locally for spinach. Heading 7 (' Yields ') shows, in the first line, the yields as harvested (' on head ', ' in shell '—and this information is entered in the first box, the second showing the actual yield) and the yield of haulms, stover, hay, etc. (again this information is entered in the first box, the yield per plot in the second and the yield per acre in the third). In the second line, the final dried, threshed yield per plot and per acre, and the threshing percentage are recorded, together with a calculated yield per acre on the basis of a 100 per cent stand.

Heading 8 is a most important one, because this section, if properly kept, can give a very good idea of the *reason* for the failure of the variety, if it fails, and several years of such records can be invaluable in deciding whether the introduction should be discarded, and deciding against reintroduction and re-trial ten years or so later.

At the end of each season, each page of the record book is copied on to a record card, and these cards are forwarded to the Research Headquarters for the central records system. The ' cards ' (more recent editions have been printed on heavy grade paper) measure 8in. × 5in., so that they can be filed in Moore's Modern Methods binders* of that size. The format is exactly the same as on the Record Book page, with the addition of boxes for Station and Year, headings 1 to 7 being printed (slightly smaller than in the record book) on one side of the card and heading 8 on the reverse. These cards are at present filed under the individual crop in the Moore's binders.

It is not suggested that anything near perfection has yet been achieved in the way in which these records are kept. Chronic shortage of staff at all stations is a continuing difficulty, and record-keeping along with all other aspects of the work suffers accordingly from time to time. But the accumulation of data which has resulted since this form of recording was introduced in 1949 has been spectacular, and we no longer have the kind of data which was once typical: ' Variety X—introduced from Uganda, 1938; sent to Yandev 1939; discarded 1942 ' was frequently the sum total of the information available on minor or unsuccessful introductions.

FIELD EXPERIMENTS

The programme of field trials to be carried out at Research Headquarters and substations and at the experiment stations and on farmers' land in

* Obtainable from Moore's Modern Methods, 19–21 Farringdon Street, London, E.C.4, these binders in their various forms and sizes have been found extremely useful for all forms of loose-leaf filing.

the twelve provinces is decided each year at a series of Cropping Scheme meetings, at which the specialist staff and the provincial staff are fully represented. The Agronomy section of the Research Organization acts as the coordinating body for these field trials, and is responsible not only for sending to all provinces the details of the trials agreed on, but also subsequently for the statistical analysis of the results, their presentation in summary form, and the maintenance of the Headquarters records of them.

Immediately after the Cropping Scheme meetings, the experiments are listed and given numbers. The numbering system consists of: (*1*) a code letter indicating the experiment station, (*2*) a serial number for the experiment (these numbers run serially, starting at 1 at each station each year), and (*3*) the last two figures of the year of the experiment, in parentheses. There are two modifications of this: in a continuing trial, the original number is retained, the last two figures of the current year are added; and in a repeat of an earlier trial, the original number is retained, and the letter R followed by the year of the new trial is added. Finally, where trials are sited off the main farms (whether on minor Government farms or on farmers' land) the letter P follows the initial letter of the main station. The following examples will make the system clear:

K 10 (50)—experiment No. 10 carried out at Kano in 1950.
K 10 (50) 54—the fifth year of the above experiment (same site, same randomization).
K 9 (50) R 53—a repeat in 1953 (different site, different randomization) of trial No. 9 laid down on Kano farm in 1950.
K 9 (50) R 53 (54)—the second year of the above trial.
KP 12 (52)—trial No. 12 of the Kano farm programme for 1952, but carried out elsewhere than on the main farm.

EXPERIMENT LOG BOOKS

Each experiment has an experiment log book, in the form of a foolscap book of 48 or 96 numbered pages with cardboard covers. It is found most convenient to have an ' arithmetic book ' ruling ($\frac{1}{3}$in. squares) rather than a plain ruling, since this leads to much neater columns of figures and quicker preparation of tables. The object of the log book is to provide a *complete* record of the experiment, so that anybody wishing at a later date to re-assess the experiment can find the whole thing in one place, and does not have to search through miscellaneous old files and loose sheets of paper.

The layout of the books is standardized, as follows (odd numbered pages on the *left*):

pp 1– 2—cyclostyled instructions on the proper keeping of log books are gummed in on the first two pages of each book. This page is signed by the assistant in charge of the experiment on receipt of the log book, and should he hand over during the course of the trial, it is again signed by his relief. The first of these signatures is taken as indicating that the assistant fully understands the details of the trial and what is required of him ; the second and subsequent signatures indicate, in addition, that the relief is satisfied with the condition of the trial and of the log book at the time of taking over.
p 3 —experiment number and title, followed by reference to numbers and titles of previous relevant trials if any.
p 4 —the object of the experiment, fully explained if necessary, with background information which may have led up to the experiment.
pp 5–10—correspondence extracts (copied in, or typescript copies gummed in). All correspondence relating to the experiment is entered here as received, with cross-reference to the file in which the original is filed. This is a very important section, and is continued later in the book if the 6 pages allocated are insufficient.

p 11 —layout plan, with reference marks, so that the site can be accurately re-identified in later years if necessary.

p 12–13—details of site, layout type, plot sizes and discards, treatments, manuring, previous cropping and manuring of the field over several years. The treatment details are *always* on p 12 (not p 13) so that they can be read simultaneously with the layout plan.

pp 14–15—routine of operations to be carried out, with details of methods to be adopted where necessary. List of minimum observations and counts required.

pp 16–19—details of operations. This starts with a tabular record on p 16, the columns being headed : Date, Nature of Operation, and Name of headman, Labour used (3 columns for number of men, women and boys), and cost (*£ s. d.*). On pp 17–19 are any notes of these operations (e.g. plots completed each day, where an operation takes more than one day ; any variations in the laid-down routine, and reasons; any difficulties encountered in carrying out the operations, etc.).

pp 20–25—observations. Periodical observations on the trial as required. These observations are made both by the Assistant and by the Agricultural Officer. Particular attention is given in this section to marked patchiness in individual plots, resulting from old anthill or tree sites, etc. Where these markedly affect the plot growth, the area is pegged when the effect is most visible, and the exact location of the pegs is noted in a plan on these pages. In extreme cases, the pegged and unpegged areas are harvested and recorded separately, so that a weighted plot-yield can be used if this appears appropriate. Whenever possible, observations are supported by plot-by-plot scoring, and this provides a much better assessment than a generalized verbal comment.

p 26 onwards—tables of counts, yields, etc. throughout the season—the layout of this section clearly depends on the nature of the trial. These are followed by the statistical analyses and calculations, the summary of results, and the discussion of these results.

The preparation of the skeleton log book is a divided responsibility. For complex trials, the books are prepared by the Agronomy section (or other specialist section concerned) in some detail, including layout plan with randomization ready supplied, and if necessary pro forma tables for entering observational data. With straightforward simple layouts, the book may be sent blank to the outstation and be prepared there. It will be appreciated that, with log books now running at about 500 per year, the preparation of them all, expeditiously, and in full detail in the short time available after the Cropping Committee meetings, by a single section would be a very difficult matter, though it would undoubtedly lead to greater uniformity.

Immediately on completion of the trial and of the tables of counts and yields, the outstation dispatches the log book (by registered post) to Research Headquarters, where the analysis, summary and discussion section is completed by the Agronomy section (in cooperation, if appropriate, with any other specialist section concerned in the trial). Only the summary of the calculations (i.e. tables of analysis of variance, etc.) is entered in the log book, but the rough working sheets are retained and filed in Moore's binders, and can be referred to later if necessary.

A typed foolscap size summary of the trial is next prepared. This includes the number, title, subject of the experiment, the main data from pp 12–13, dates of main operations from pp 16–19, any important observations from pp 20–25, standard error and coefficient of variation (but not normally the table of analysis of variance), tables of main effects and interactions of yields per acre with significant differences indicated (and of stand counts or other observations if appropriate), summary statement and recommendation for further work. In continuing experiments the main yield data from previous years are also included. A copy of this summary (which usually

occupies 2–3 pages of typescript) is sent to the station concerned, where it is filed in a Moore's binder. Copies are also sent to the Headquarters of the other Regions of Nigeria, of the Federal Department of Agricultural Research, and of the University College, Ibadan. The Research Headquarters copies of these summaries are kept in Moore's binders, one binder per station. They are in general filed in serial order of experiment number for the year (e.g. in the Kano binder, the 1955 summaries would be filed in the order K1(55), K2(55) etc. and would be followed by the 1956 summaries, K1(56) etc.). In the case of *continued* or *repeat* experiments, the continuations or repeats are filed immediately after the *original* number: thus, in the 1955 series above, if K2(55) were a continuing experiment, the sequence would be K1(55), K2(55), K2(55)56, K2(55)57, K2(55)58, K3(55) etc. It is found that this system, combined with an annual index of trials, provides the quickest way of finding close together the records most likely to be needed together.

The log books themselves are retained (in steel cupboards) at Research Headquarters. They are not reissued except sometimes in the case of continued experiments of a minor nature when the observations, operations and data are continued in the same log book. Once the log books are in the storage cupboards, they are treated as library books, are issued only against signature and are followed up to ensure their return.

OTHER TRIALS

Non-statistical observation trials on a larger scale than the farm garden also need to be recorded, and it has become more and more accepted that these are best given numbers and log books on the same lines as the formal statistical trial. The layout of these log books is not standardized in the way outlined above, but the same principles are followed and the officer concerned makes out his log book as best suits the particular case. As an example, a very complete log book (now in its second volume) has been kept on the subject of an experimental underground grain storage tank. This contains complete details of the construction and filling of the tank, of the difficulties met with, of gas analyses of the internal atmosphere of the tank, and of the condition of the grain before and after storage. It also contains suggestions for avoiding the difficulties in future tanks.

It has in general been found that the best way to ensure the completion and recording of an observation trial, no matter how simple, is to give it an experimental number and log book.

PUNCHED CARDS

As stated above, copies of the typescript summaries are filed at Research Headquarters in Moore's binders by stations. They present a very large volume of paper, and without elaborate cross-referencing are extremely difficult to sort by subjects or by crops. It has therefore been found convenient to copy the main data from the summaries on Copechat* punched cards (*Figure 2*). These cards present an even more condensed version of the trial than do the typescript summaries. The site and plot data appear on the

* Supplied by Messrs Copeland Chatterson Co. Ltd, Exchange House, Old Change, London, E.C.4.

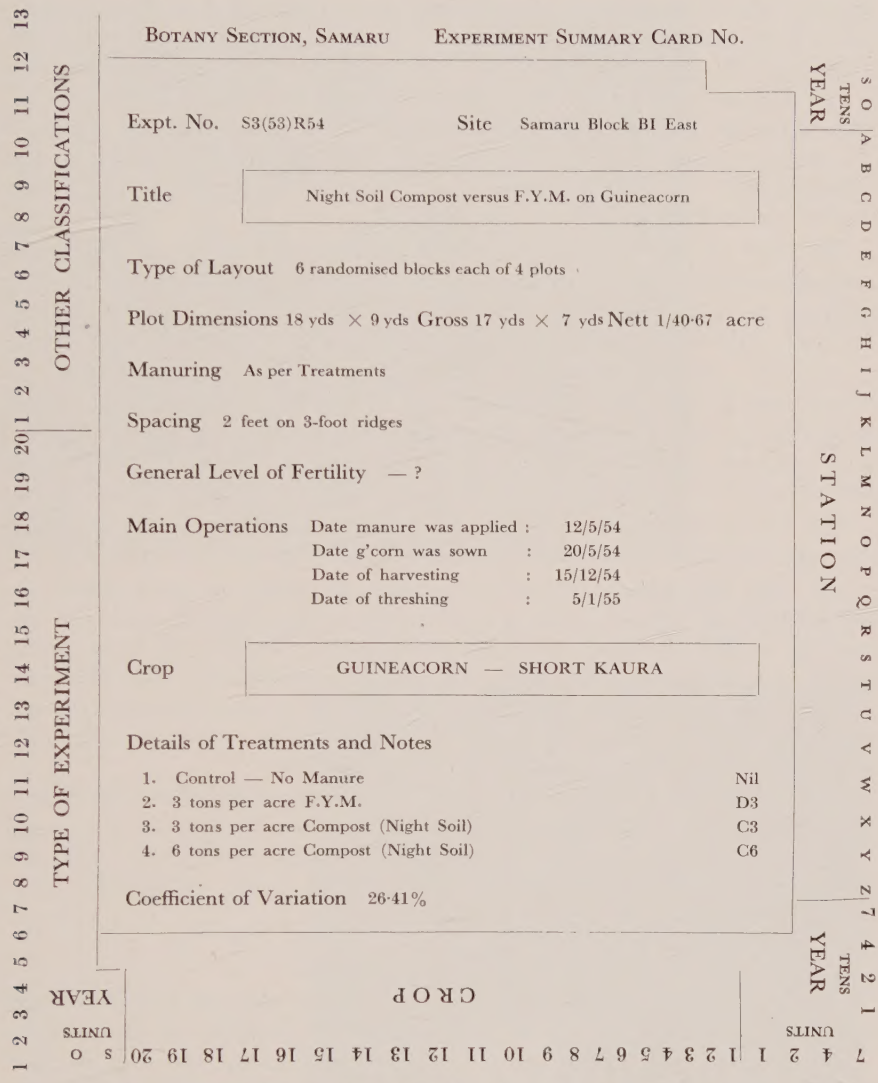
BOTANY SECTION, SAMARU EXPERIMENT SUMMARY CARD No.
Expt. No. S3(53)R54
Site Samaru Block BI East
Title
Night Soil Compost versus F.Y.M. on Guineacorn
Type of Layout 6 randomised blocks each of 4 plots
Plot Dimensions 18 yds × 9 yds Gross 17 yds × 7 yds Nett 1/40·67 acre
Manuring As per Treatments
Spacing 2 feet on 3-foot ridges
General Level of Fertility — ?
Main Operations
Date manure was applied : 12/5/54
Date g'corn was sown : 20/5/54
Date of harvesting : 15/12/54
Date of threshing : 5/1/55
Crop
GUINEACORN — SHORT KAURA
Details of Treatments and Notes
1. Control — No Manure Nil
2. 3 tons per acre F.Y.M. D3
3. 3 tons per acre Compost (Night Soil) C3
4. 6 tons per acre Compost (Night Soil) C6
Coefficient of Variation 26·41%
OTHER CLASSIFICATIONS
TYPE OF EXPERIMENT
STATION
YEAR
CROP
YEAR
TENS
UNITS

Figure 2. Contents of a typical punched card summarizing experimental data

front of the card (see *Figure 2*) while the yield summary tables are typed on the back. Two entries on the front appear in ' boxes '—the title of the experiment and the test crop—and these entries are found to stand out well when presented in this manner. Though very condensed, the cards give sufficient data to enable the worker to decide whether he needs to look at the fuller summary or the log books.

The cards are border-punched on three sides for sorting: (*a*) by Stations, (*b*) by year, (*c*) by crop, (*d*) by type of experiment and (*e*) by ' other classifications ', parts of each border including the identifying punch-hole being clipped away to signify. It is not proposed to describe the coding system in

detail—anyone proposing to use these cards should obtain expert advice from Copeland Chatterson on the design of a code to meet the particular requirements. A few comments on the classifications, however, are included.

(a) *Stations*—The same letter code is used as for the experiment numbers. The cards are so numerous that it is found most convenient to store them by stations rather than extract by station by the needle. However, the clipping of the station hole makes it very easy to spot if a card has got into the wrong station.

(b) *Year*—We have found it very rarely necessary to sort by year, and moreover when all cards are punched very close to the corner they become difficult to handle and tatter very quickly. We therefore no longer punch for years—these holes in fact are used as ' decimals ' to indicate minor crops.

(c) *Crop*—We have 20 main holes, and the year holes as decimals. A single hole is allocated to each main crop of the Region (sorghum, millet, groundnut, cotton, etc.). Minor crops are dealt with in groups (e.g. other root crops group, other cereals group, etc.) with a main number, and the individuals in that group each have one of the decimal holes.

(d) *Type of experiment*—Experiments here are classified into such types as Varietal Trials, Fertilizer Trials, Spacing Trials, etc.

(e) *Other classifications*—These are at present nearly all spare holes, not yet committed. One of them is reserved for meteorological data from the various stations, another for cards which include fodder (or stover, etc.) yields in addition to grain yields, another for costings data. For this type of data (which does not fit on the pro forma type of card) special cards are used in which the central printing illustrated in *Figure 2* is omitted, only the marginal (classification) headings being retained.

The Farm Garden record cards now form such a bulk of records that it is becoming increasingly laborious to bring together the records of a single introduction or selection over a period of years and at a number of different stations. Consideration is therefore being given to the introduction of a punched card for these records also.

WEIGHING AND COUNTING

There are many details of field technique which we have tried to reduce to a standard routine in order to increase the reliability of the records. These cannot properly find a place in the present paper, but it is felt that an exception must be made in the case of the arrangements made for experimental weighings and counts, since without accuracy in weights and measurements, detailed recording is so much wasted effort.

Unsatisfactory details of weights presented for analysis were found to arise from two main sources, namely (*1*) the use of spring balances which had become unreliable through rough farm use or were insufficiently sensitive for small plot yields, and (*2*) errors of arithmetic arising from the use of pounds and ounces in weighing and the subsequent conversion of these data either to ounces or to decimal pounds. It was decided therefore to introduce standard counterpoise (not spring) balances to all stations, to have these graduated in decimal pounds, and to insist that they were reserved for the weighing of experiments only.

Figure 3

Figure 4

The two machines decided on are illustrated in *Figures 3* and *4*. The Towers Rotating Weight Balance* weighs, by a combination of pan weights and rotating sliding scale, to 14 lb, and is accurate to 0·001 lb (the slider being graduated in decimals of a pound). In spite of its sensitivity, this balance is not only very robust, but it also gives a reasonably quick reading. This balance is used for plot weights of 10 lb and downwards, and is read to sufficient accuracy to give three significant figures for analysis. The makers have supplied, as a special order, wooden carrying cases for these machines, in which the machine, pan weights and scale pan fit securely. The case carries a padlock, and the key is kept by the assistant in charge of experiments, who is responsible for the proper use of the balances. If the balance is required in the field, it is carried there in this case, and is set up on top of the case, with temporary wind shields if necessary.

For weights above 10 lb, a steelyard† is used. The main scale here reads to 60 lb by $\frac{1}{2}$ lb, and the micrometer rider subdivides the $\frac{1}{2}$lb to tenths of a lb. Plot yields exceeding 60 lb are weighed in separate parcels on the steelyards.

The accuracy of stand counts is very greatly increased by having duplicate counts made by two observers, each provided with a hand tally counter. These counters have a tendency to go out of order after a short time in inexpert hands, but our experience has been that the E.N.M. hand tally counter‡ is the most reliable in this respect of those so far tried.

The system outlined above is not, of course, entirely satisfactory in all respects. The storing of log books at Headquarters causes inconvenience at times to workers at the outstations where the experiments were carried out, but in the interests of security we have so far resisted requests to store them at the provincial stations. The possibility of microfilming the books for the Headquarters Records is at present under consideration, and it would appear that the expense might be justified.

Again, the risk involved in sending the books about the country is not negligible, even though registered mail is always used, and the risk of loss while on loan still remains. Microfilms would overcome most of these hazards.

No system of recording can overcome completely the deficiencies of the recorder, and, as with Farm Garden records, the log books are by no means all kept to the standard we would desire.

Copying has been reduced to the minimum wherever possible, but errors of copying do occur, and the checking system is not entirely adequate on this point.

Thus the system cannot be regarded yet as by any means final, but we have been very gratified by the favourable comments on it by Mr Nye and by other knowledgeable visitors.

* Rotating Weight Balance, Model 177S (0–14 lb by 0·001). J. W. Towers Ltd, Victoria House, Widnes, Lancs.

† Buck and Hickman, 2 Whitechapel Road, London, E.1; Catalogue Fig. 435, but the decimal gradation on the rider must be specially ordered.

‡ English Numbering Machine Co., 25 Queensway, Ponders End, Enfield, Middlesex.

(*Received June 1958*)

The Development of the Poultry Industry in Cyprus

H. Hirst* and A. Agrotis†

Department of Agriculture, Cyprus

From the time of the British occupation of Cyprus in 1878, the size and quality of its poultry have been steadily improved through the introduction of exotic blood, chiefly from Britain. Some introductions were made by private enterprise; others, especially during the past half century, by the Department of Agriculture. There are several official records of the introduction of Rhode Island Red and Light Sussex blood, mainly of the former.

Up to mid-1945 all poultry was kept, on a small scale, by villagers and also by urban residents. In a 1946 census of agriculture the poultry population kept by farmers was placed at 396 000. It is thought that the total then kept, including those belonging to non-farmers, was over 1 000 000 head. Poultry were invariably kept on utility lines, mainly on household scraps and what they picked up by ranging, and poultry fanciers were more or less non-existent.

Before 1939 the Department of Agriculture maintained small flocks of pure bred poultry at its main livestock farm at Athalassa, situated near the Island's capital city of Nicosia, and also at a number of stud stables located throughout the Island. Eggs were sold for natural hatching during the spring and summer months and surplus cockerels of pure breeds, chiefly Rhode Island Red, were issued for breeding purposes in the villages. Before 1939 the prices of both eggs and poultry, sold for table purposes, were invariably very low and were certainly not conducive to the encouragement of specialist poultry keeping.

The problems associated with the development of the poultry industry to meet the demand for eggs and table birds, which had been stimulated by wartime prosperity, were studied in connection with a Ten Year Development Programme which was introduced in 1946. With the aid of Colonial Development and Welfare funds the Athalassa Poultry Unit was enlarged, residential quarters for its senior staff were built and the services of an overseas female poultry officer were obtained, mainly for the purpose of training three young Cypriot girls, two Greek and one Turkish, in modern methods of poultry husbandry. At this time a number of short courses in poultry husbandry were organized for the benefit of other junior personnel of the Department. The training of the three local poultry instructresses, which included some overseas experience, proved very successful and in due course they were allocated areas of the Island in which to carry out extension activities.

In 1950 it was decided to give a male Cypriot officer, who had taken a general course in agriculture in the United Kingdom, specialist training in poultry husbandry with a view to the local replacement of the overseas

* Deputy Director

† Agricultural Superintendent (Poultry)

poultry officer. On the return of this officer to Cyprus, with the National Diploma in Poultry Husbandry with honours, it was decided to concentrate on the development of three Poultry Units on Government projects—two on the main Government farms and another on the farm associated with a Rural Central School for Turkish students. Each of these well laid-out units had breeding pens, rearing grounds and hatcheries specializing in the production of day-old chicks. The activities of the three poultry units proved so popular with the public that they were later increased to seven, complete with hatcheries, and two smaller units without hatcheries. The hatcheries all have modern cabinet-type incubators installed and by the start of the 1958–59 hatching season their combined output of day-old chicks will have reached 15 000 per week during a long hatching season. The entire output of these incubators, apart from that needed for replacement stock, is taken up by small poultry keepers who have been surprisingly successful in rearing the day-old chicks and whose demand so far, especially during the spring months, appears almost insatiable.

The breeds kept on the Government poultry units have been chiefly Rhode Island Reds and to a lesser extent Light Sussex. Other breeds kept in relatively small numbers are North Holland Blue, White Leghorn, Maltese and Cyprus Blacks and Parmenter Reds. Some crossing between the pure breeds has taken place for the production of chicks for issue to villagers and other small keepers.

Until recently little interest has been shown in the establishment of large scale commercial egg-laying units but there is a very different story to tell as regards broiler poultry. Following small scale trials in the intensive production of table birds, by the Department of Agriculture at Athalassa, and by private persons who had had experience of the broiler industry in Israel, a very rapid development of the industry has taken place and it is estimated that by the end of 1958 the rate of production may reach as much as 750 000 per annum. The largest unit has been developed on the Northern Mountain (Kyrenia) Range by Mr P. O. G. Wakeham who originally planned an egg-producing unit but quickly changed to broiler production to meet the demand which has developed in Cyprus since 1945 for all forms of fresh meats. A local company has been formed, under the chairmanship of Mr Wakeham, and after the setback of a disastrous fire in 1956 the project has gone ahead very successfully and is now turning out excellent quality broiler poultry at the rate of some 350 000 per year (which is estimated to be some 60 per cent of the total Island production). At present this poultry project, known as the Bellapais Farm, can accommodate some 80 to 90 thousand chicks of all ages.

The Bellapais Farm, and most other broiler producers, obtain practically all their chicks, as day-olds, from Israel. The chicks are either New Hampshire or New Hampshire/White Leghorn crosses. Reverting to the Bellapais Farm, which is under the management of an experienced Israeli technician, Dr Z. Goldstein, intensive modern techniques are employed through its various sections. In the wooden brooder houses the chicks are kept, for the first six weeks, on the floor with hot water pipe brooders running the full length on either side. After this the grower chicks are placed in metal fattening cages made on American lines. When the birds reach a live carcass

weight of 2½ to 3 lb, which is usually at from 10 to 12 weeks of age, they are slaughtered. The Farm has modern facilities for plucking, eviscerating, chilling and storing the carcasses. The sale of the Bellapais broiler poultry is undertaken by an affiliated company. The poultry are fed on well balanced rations compounded on the Farm itself from a wide range of ingredients including antibiotics and vitamin mixtures. It is believed that the conversion ratio secured is in the neighbourhood of 1 : 3.

The poultry are kept under close supervision by the Veterinary Service of the Department of Agriculture. So far no serious disease has been encountered in spite of the prevalence on the Island of such diseases as Fowl Pest, Fowl Pox and Fowl Typhoid. Although there are no other ventures on the Island as large as that at Bellapais there are a number of others—some rapidly expanding—which are run on similar modern lines. Some difficulties have inevitably been encountered, but these have not been of a serious enough nature to deter new enterprise.

One result of the success of the local production of broilers has been the import of dressed broiler poultry, from Continental countries—chiefly Holland and Scandinavia—to meet the demand for table birds which has been stimulated. Of recent months broilers have been selling retail at around 5*s* per pound, dressed ready for cooking. The quality of the local product has been consistently good and this has undoubtedly enabled it to withstand competition from imported produce.

The reliance of the broiler industry on imported day-old chicks has been a matter of considerable concern to the Department of Agriculture, especially to its Veterinary Service. Recently there is a move to make Cyprus self-sufficient in the production of chicks for the broiler industry and several enterprises including the Bellapais Farm have plans for the necessary large scale hatcheries and supporting breeding units. One problem will be in securing the regular supply of chicks, from local sources, necessary for broiler production throughout the year. Cyprus has a climate of the extreme Mediterranean type and has in many parts very hot summers with shade temperatures going up to 110° F or even greater. The diurnal fall is usually considerable and air movement is greater than in tropical countries. Israel seems to have been fairly successful in maintaining regular supplies of chicks for broiler production. Various techniques have been developed including staggered hatching of breeding stock, and special hatching techniques in hot weather including great care in the storage of eggs at low temperatures from laying to setting.

The Department of Agriculture in Cyprus has recently established two experimental poultry units on its hill stations—one at around 4 500 feet. At the lower of the two stations (about 2 000 feet), it has built a hatchery, the incubator room of which could be air-conditioned if it proves necessary. Trials are being carried out with a view to extending the hatching season by keeping breeding stock under semi-intensive systems at relatively high altitudes.

On one of its estates in the southwestern coastal part of the Island, the Department is also establishing a 10 000 bird laying unit on semi-intensive lines. Part of this unit is to be stocked this year with New Hampshires from

Israel which it is hoped will provide nucleus stock for the development of a day-old chick industry for supplying the broiler trade.

The Veterinary Service is anxious to keep the Department's units clear of Chronic Respiratory Disease which is believed to have been introduced into Israel from the U.S.A. and which may well be causing some loss to the local broiler industry.

Figure 1. Modified Malta poultry house originally used on Poultry Units. The house is 12 ft × 6 ft and will accommodate 75 birds of a large breed

Figure 2. Semi-intensive flock houses developed by the Department of Agriculture. Walls are of hollow concrete blocks. Window space is minimal to give shade during the heat of the day; the holes at ground level provide ventilation. Each house is 120 ft × 30 ft and will hold 1 200 birds. The young olive trees will provide shade in due course

The Department of Agriculture has taken considerable interest in the design and construction of poultry houses, both of the small breeder and large flock house types, suited to the local climatic conditions. In the larger houses extensive use has been made of hollow blocks and bricks to give cavity walls. Brooder houses and incubator rooms have been insulated by lining with various materials, such as plaster board which is manufactured locally.

As regards growing stock and adult birds, considerable attention is being paid to giving the stock adequate shade from the sun. During the summer months of the year sun temperatures can be very high indeed and it is noted that the birds seek shade even early in the day.

Figure 3. Cypriot girls in the Bellapais poultry farm give a final dressing to broiler poultry which have been mechanically plucked

As regards the village industry, the chief difficulty in its expansion in recent years has been outbreaks of Newcastle Disease which recently has become more or less endemic on the Island. The disease, which has only made its appearance on the Island during the past six years, was brought under control on two occasions by an Island-wide vaccination campaign. It has flared up again after periods when it seemed to have been eliminated. The collaboration of the small poultry keepers in the necessary quarantine and immunization measures has not always been all that could be desired. The movement of poultry for slaughter purposes, especially at festive occasions, has proved difficult to control. Many owners have proved reluctant to bring laying birds for immunization because of the check in production which invariably takes place. As a result of the incidence of Newcastle Disease in village poultry, egg prices have been high of late and this is undoubtedly stimulating interest in intensive egg production. One thing which has so far deterred such enterprise is the village poultry industry which usually produces large numbers of eggs during the spring months with the result that, under normal circumstances, egg prices drop to a level which is unremunerative to large scale intensive production. That there is scope for such enterprise is shown by the fact that the War Department is at present bringing into Cyprus about 500 000 eggs monthly for the use of the troops. In the past these have been secured from Turkey and Israel. At the moment consideration is being given to obtaining supplies from Denmark and

building cold stores for their storage. The building of the cold stores may well result in a stimulation of local production to meet Service requirements.

This brief review of the poultry industry in Cyprus would be incomplete without mention of the local compound fodder industry. During 1939–45 and early post-1945 years the Department of Agriculture stimulated a demand for compound fodders by running its own scheme for supplying livestock keepers with a wide range of balanced feeds. This scheme was abandoned when official action no longer appeared necessary. During recent years two private compound fodder companies have come into being. They have modern plant for mixing and processing and can turn out compressed cubes and poultry pellets. The local availability of baby chick food and grower mash has undoubtedly contributed to the rapid progress made in the poultry industry. During a recent visit paid by Dr H. Engler, the F.A.O. Poultry Specialist, it was stated that with the exception of Israel, Cyprus is well ahead of other Middle East countries in the development of the poultry industry.

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The Effects of Arboricides on East African Trees and Shrubs—I

Acacia Species

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Acacias occur throughout Africa in a very wide range of vegetation types and are particularly characteristic of the thornbush and wooded grassland or savannah areas. There are numerous species, 50 indigenous species being listed from East Africa alone (Brenan and Greenway, 1949). All the indigenous species are thorny and some of them are among the most troublesome of the woody plants which invade grazing lands. *A. hockii* De Wild (until recently *A. seyal* var. *multijuga*), for example, is a serious problem in Uganda (Harker, 1957), *A. seyal* Del., *A. senegal* (L) Willd., *A. hebecladoides* Harms and *A. subalata* Vatke. are commonly encountered in Kenya (Bogdan, 1954) and *A. lahai* Steud and Hochst. is widespread in some of the higher altitude pastures. The same species are also of importance in Tanganyika where, in addition, *A. zanzibarica* (S. Moore) Taub. is a problem in some coastal areas.

All these species are small trees whose establishment in grassland appears to be encouraged by grazing and the exclusion of grass fires. Under such conditions, and especially where the grassland is grazed too heavily, a dense growth of trees can develop. Harker (1957), for instance, has recorded up to 800 *A. hockii* trees per acre in the Ankole district. This bush growth seriously limits grazing and the restriction of cattle to paths between the trees leads to conditions favouring erosion. If the trees are cut down the grazing is improved temporarily but regrowth from the stumps develops rapidly and the mass of thorny shoots near ground level soon limits the grazing even more than the original trees. Continued cutting or burning every few years is thus needed to keep the regrowth under control.

Of a different type to the above mentioned trees is the climber *A. pennata* (L) Willd. This species is widespread throughout East Africa and is a very common constituent of evergreen or deciduous thickets and of riverine forest. It does not normally occur in open grassland but where thicketed country is cleared to produce pasture it is frequently one of the main constituents of the regeneration (Ivens and Cochrane, 1956). It is extremely difficult to eradicate because of its extensive underground root crown and its ability to withstand repeated cutting and burning.

Many of the tree species which invade pasture land are also encountered in bush clearing for tsetse control. In addition to these some of the larger Acacia species such as *A. nigrescens* Oliv. and *A. tortilis* (Forsk.) Hayne (= *A. spirocarpa* Hochst. ex A. Rich), must frequently be eradicated as constituents of tsetse habitats. Like the smaller species these trees generally produce regrowth from the stumps when they are felled and periodic slashing

of the regeneration is needed if a cleared area is to remain unsuitable for tsetse or if it is to be used for grazing.

PREVIOUS WORK WITH ARBORICIDES

The first tree-poisoning trials in East Africa were carried out in 1921 by Swynnerton and the work was extended in 1929–30 by Napier-Bax (Swynnerton, 1936; Napier-Bax, 1936). The trials were conducted on a wide range of tree species of importance in tsetse habitats in Tanganyika, among which were included several species of Acacia. The chemicals tested included various arsenic compounds, sodium chlorate, copper compounds, etc. and, of these, the most effective was arsenic pentoxide applied as a solution in water to frills at the base of the trunk. It was concluded from these trials that ring-barking without chemical treatment was the cheapest method of killing mature Acacia trees but that better results were obtained on immature trees by using arsenic.

The effectiveness of arsenic was confirmed in South Africa but this chemical was never used widely because of its high toxicity to man and livestock and in trials conducted in 1938–39 on ' thorn trees ' (*Acacia* spp.) it was found that ' power paraffin ' could also be used as an arboricide (Scott, 1940). This material was safe and inexpensive but, in order to obtain consistent results, it was found necessary to expose the trunk to a depth of 2 to 3 in. below the surface and apply the oil to this zone. West (1947) also tested paraffin on Acacias in Rhodesia but reported the method as unreliable and obtained better kills with arsenic pentoxide or sodium arsenite applied to the stumps.

The introduction of the non-toxic, plant growth-regulator type herbicides in 1946–47 and the discovery that some of these compounds, in particular 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), could be used for killing trees greatly stimulated research into methods of tree killing and these chemicals have now been tested on a wide variety of woody plants in all parts of the world. The methods of application which have given the best results are sprays applied either to the base of the trunks or to cut stumps, using ester formulations of the chemicals dissolved in diesel oil. For much branched shrubs with no main stem, where basal spraying is difficult, overall foliage sprays with ester emulsions in water have sometimes proved effective. In the U.S.A., Young *et al.* (1951) found that the most successful treatment of *A. farnesiana* was a basal trunk spray of 2,4,5-T ester in diesel oil at a concentration of 1·0 per cent, while on *A. amentacea* the best results were obtained with 0·4 to 0·6 per cent solutions in oil applied to freshly cut stumps. Darrow *et al.* (1953) also conducted trials on *A. farnesiana* with 2,4,5-T ester and obtained good results with a 1·0 per cent solution in oil as a basal or stump spray. Higher concentrations gave no increased effect and foliage sprays only gave partial kill of the trees.

Some of the earliest trials of the growth-regulator chemicals on trees in East Africa were carried out in 1951–52 on *A. lahai* by Plant Protection Ltd in cooperation with the Kenya Department of Agriculture (Kenya, 1953). The chemicals used were ester formulations of 2,4-D and a 3 : 1 2,4-D/2,4,5-T mixture. The results suggested that the mixture containing 2,4,5-T was

considerably more effective than 2,4-D alone and that, when applied as basal sprays, solutions in diesel oil gave much higher kills than emulsions in water. Applied to stumps, however, there was less difference between the oil and water sprays. Applying the chemical to the whole stump gave better results than spraying the top of the stump only and there was evidence that higher kills were obtained if the stumps were split vertically before treatment.

Trials have also been carried out in South Africa and 2,4,5-T ester in diesel oil or paraffin at concentrations of 0·8 to 2·0 per cent is recommended as a basal spray for the control of *A. karroo* and *A. heteracanthus* (Union of South Africa, 1955, 1956; NAUDE, 1956). In Rhodesia, however, relatively little success with 2,4,5-T and 2,4-D/2,4,5-T mixtures has been achieved on *A. rehmanniana* (McKAY, 1955).

THE PRESENT SERIES OF EXPERIMENTS

Materials and methods

The series of trials on Acacia species described in this paper was started in 1954 to 1956 in various parts of Tanganyika and Kenya. The principal arboricides tested were ester formulations of 2,4,5-T (*n*-butyl ester) and 2,4-D (*iso*propyl ester)*. In a few trials treatments with other chemicals, including MCPA(4-chloro-2-methylphenoxyacetic acid), ammonium sulphamate and monuron [CMU or *N*-(4-chlorophenyl)-*N'*,*N'*-dimethylurea] were also tested. The chemicals were applied mostly as basal bark or stump sprays using either diesel oil or water as a carrier and, in most trials, a comparison was made between basal bark treatments applied to the undamaged trunk and to trunks which had previously been ' frilled ' at the base. The frills consisted of a ring of overlapping, downwardly directed cuts made as near ground level as possible.

The sprays were applied with an Oxford Precision portable sprayer at a rate sufficient to wet the treated zone thoroughly and to allow a certain amount of run-off. With the basal bark sprays a band round the trunk from ground level to a height of 6 to 9 in. was treated and, in general, it was found that this required a volume of 20 to 30 ml of liquid per inch diameter of trunk. A similar volume was applied to stumps. Where trunks were frilled, the spray was applied so that much of the liquid ran into the frill but enough was used to wet the bark between the frill and the ground as well.

Observations on the effects of treatment were made as frequently as possible. During the periods when the trees were normally in leaf the degree of defoliation caused by treatment was estimated visually and effects on the bark at the base of the trunk were noted. When observations were made during the dry season, during much of which period the trees were normally leafless, it was only possible to record effects on the base of the trunk. In the later observations signs of disintegration of the crowns of the trees were noted and particular attention was paid to recording the appearance of regenerating shoots at or near the base of the trunk.

EXPERIMENTAL RESULTS

(a) *Small tree Acacia species*

(*1*) *Acacia hebecladoides*—The majority of the trials on the small tree Acacia species have been conducted on *A. hebecladoides*, a tree growing to a height

* Concentrations of these two chemicals are expressed throughout as weight/volume percentage of acid-equivalent

of 10 to 15 ft. When felled it produces regrowth not only from the above-ground part of the stump but also from a zone about 3 to 6 in. below ground level.

The first trial was sprayed near Arusha, Tanganyika, in January 1955 during the brief dry period between the short and long rains when the trees were in full leaf and actively growing. Each treatment was applied to a group of ten trees. The details of the treatments applied and the results of observations made at various intervals after spraying are shown in *Table 1.*

Table 1. The effects of various 2,4,5-T and 2,4-D treatments applied to standing Acacia hebecladoides *trees during a period of growth (January) and at the beginning of a dormant period (August)*

Date sprayed		*January 1955*			*August 1955*		
Months after treatment		2½	5	9	3	15	15
Treatment		*Per cent leaf fall*	*No. dead*	*Regrowth absent*	*Per cent leaf fall*	*No. dead*	*Regrowth absent*
1. *Frilled, unsprayed*		7	0	1	10	0	4
2. *Frilled, diesel oil*		59	9	1	95	9	4
3. *Frilled, 2,4,5-T*	0·5%	100	10	6	100	10	3
4. *ester in oil*	1·0%	100	10	7	100	10	4
5. *No frill, 2,4,5-T*	0·5%	99	10	5	100	8	2
6. *ester in oil*	1·0%	100	10	9	99	10	2
7. *Frilled, 2,4-D*	0·5%	86	9	4	100	10	0
8. *ester in oil*	1·0%	93	9	2	99	10	0
9. *No frill, 2,4-D*	0·5%	—	—	—	62	9	1
10. *ester in oil*	1·0%	—	—	—	88	10	0
11. *Frilled, 2,4,5-T*	0·5%	21	0	5	—	—	—
12. *emulsion in water*	1·0%	27	0	4	—	—	—
No. of trees/treatment			10			10	
Volume of spray/tree			70 *ml*			85 *ml*	
Mean basal diameter			2·3 *in.*			2·8 *in.*	
Estimated trees/acre			500			500	
Volume of spray/acre			7·8 *gall*			9·4 *gall*	
Chemical/acre at 1·0%			0·8 *lb*			0·9 *lb*	

The initial effects on the trees were relatively rapid. Within 2 to 3 weeks many of the treatments had caused the leaves to turn yellow and the estimates of the degree of defoliation occurring after 2½ months show that both 2,4,5-T and 2,4-D in diesel oil caused almost 100 per cent leaf fall. Even diesel oil alone had a marked effect on frilled trees and after 5 months 9 out of the 10 treated trees were entirely leafless. 2,4,5-T in water, however, was considerably less effective than the oil solutions or oil alone. After 5 months the trunks and branches of all the trees which were leafless at the earlier observation were dead and drying up. 4 months later some had rotted at the base and fallen and others could be pushed over by hand. The trees which were alive after 5 months remained healthy as long as observations continued.

The final results show that all the oil-based treatments gave effective kills of the above-ground parts of the trees but that 2,4,5-T was ineffective in

water. The trunk was not always killed below ground level, however, and a number of trees produced new growth from below the treated zone.

Regrowth was first noted after 5 months, some shoots had reached a length of 3 ft after 9 months and were up to 6 ft long after 21 months. The table shows that the 2,4,5-T treatments considerably reduced the degree of regeneration. The reduction was greatest with the 1·0 per cent concentration applied without frilling and with this treatment only one tree out of ten bore basal regeneration after 9 months. With the 2,4-D treatments there was more regrowth than with 2,4,5-T and, although diesel oil alone killed the tops of the trees, it had no inhibiting effect on the growth of shoots from below ground. 21 months after treatment it was no longer possible to identify many of the sprayed trees but, from those which were located, there did not appear to be any appreciable increase in the number regenerating.

In order to obtain information on the relative effects of arboricides applied at different times of year, the experiment described above was repeated in the same locality in August 1955, towards the middle of the long dry season, when the trees were beginning to lose their leaves. The results of the second trial are also shown in *Table 1* and it is seen that, as in the first trial, 2,4,5-T and 2,4-D brought about almost complete defoliation in 3 months. Diesel oil alone on frilled trees caused more rapid leaf fall in the second trial, probably because of the drier conditions, but the final effect of this treatment was the same. The drier conditions may also have been responsible for the fact that the trunks of the affected trees decayed more rapidly. After only 3 months the trunks were heavily infested with wood-boring larvae and the wood itself in many cases was powdery and rotten. 2,4-D applied without frilling was somewhat slower acting than similar 2,4,5-T treatments but eventually produced an almost complete kill of the above-ground parts of the trees. The main difference in the results of the two trials was in the regeneration following treatment. In the second trial regeneration appeared more rapidly than in the first and had reached a height of up to 4 ft in 3 months. In addition, a larger proportion of trees produced regrowth and, with all treatments, at least 6 out of the 10 trees had grown fresh shoots at the base after 15 months.

The results of these two experiments suggest that the most effective of the treatments tested on *A. hebecladoides* is 2,4,5-T ester in diesel oil at 1·0 per cent applied as a basal bark spray without frilling. This conclusion is supported by a number of other trials on different types of growth of the tree.

For example, in a trial on freshly cut stumps carried out in the middle of the long rains (April 1955), 2,4,5-T ester in oil at 0·5 and 1·5 per cent gave a very high degree of kill and only 10 per cent of the stumps produced regrowth in 18 months. 2,4-D ester at 1·5 per cent was less effective, however, and only killed 40 per cent.

Similar sprays applied to stumps cut a year previously were less effective. 2,4,5-T ester in oil at 0·5 per cent gave 30 per cent kill, 2,4-D ester at the same concentration killed 20 per cent while no kill resulted from 0·5 per cent MCPA ester. Amine formulations of 2,4,5-T and 2,4-D in water at 0·5 per cent were also ineffective as was ammonium sulphamate in water at 10 per cent. The poor results of this trial appeared to be due mainly to the dense masses of shoots growing from the stumps which intercepted much of

the spray solution and prevented the main trunk from being adequately wetted. Thus, although all the oil-based treatments caused a high degree of defoliation and killed many of the regenerating shoots, fresh regrowth was able to take place.

A trial was also conducted on an area of grassland where a stand of *A. hebecladoides* had been cleared by cutting about 6 to 12 in. below ground level. This was not apparently deep enough to prevent regeneration and new shoots were produced from the remaining parts of the stump. The shoots were 18 in. to 2 ft high at the time of spraying but, after treatment with 2,4,5-T ester in oil at 0·5 or 1·0 per cent, were killed in a few weeks. After 18 months approximately 20 per cent of the plants had produced fresh regrowth but the remainder were dead. The same chemical in water also killed the shoots initially but there was considerably more regrowth than with the oil solutions.

Monuron (CMU) was also tested in this trial, the wettable powder being applied to the soil at a rate of 20 g per clump of shoots. It was very slow acting, possibly because a period of abnormally low rainfall followed the treatment, and after 6 months appeared to have had little effect. After 18 months, however, it had given 100 per cent kill of the shoots and no further regeneration occurred.

(*2*) *Acacia zanzibarica*—This species is similar in appearance to *A. hebecladoides* and plays a similar part as an undesirable tree in grazing land in coastal districts. It has not yet been studied in detail but the results available at present suggest that it responds to arboricides in a very similar manner to *A. hebecladoides*. In a trial carried out at the beginning of the rainy season in 1956 using esters of 2,4,5-T and 2,4-D at 0·5 and 1·0 per cent in oil as basal bark sprays without frilling, all treatments, including diesel oil alone, defoliated the majority of the trees in 2 months. After 12 months a number of the trees receiving diesel oil alone had recovered but with 2,4,5-T at both concentrations all were dead and there was little regrowth. 1·0 per cent 2,4-D also gave 100 per cent kill with little regrowth but with the 0·5 per cent solution a number of trees survived. The data on regeneration are incomplete in this trial but it appears certain that the trees killed by spraying produced considerably less regrowth than that which follows cutting.

(b) *Large tree Acacia species*

(*1*) *Acacia nigrescens*—This species which grows to a height of 50 ft is common at lower altitudes in Tanganyika and in some areas is associated with the tsetse *Glossina morsitans*. The bark and wood of the tree are very hard and tough, so that it is a difficult species to fell or ring-bark. After felling, copious regrowth is produced from the upper parts of the stump but, as with most of the larger Acacias, there is little regeneration from below ground. *A. nigrescens* was the dominant tree in large areas of woodland forming an important tsetse habitat in the Mkata Reclamation Scheme carried out near Morogoro (E.A.T.R.O., 1956).

A trial was laid down on trees up to about 40 ft high in September 1954, in the second half of the dry season when the trees were leafless. 2,4,5-T and 2,4-D were tested as basal sprays with and without frilling at

concentrations of 0·5, 1·5 and 4·5 per cent in oil and water and *Table 2* shows the results of the treatments at various intervals after application.

Table 2. The effects of various basal sprays of 2,4,5-T and 2, 4-D esters on standing trees of Acacia nigrescens

Months after treatment		2½	6½		14	24	
Treatment		*No. leafless*	*Per cent leaf fall*	*No. leafless*	*No. dead*	*No. dead*	*No. with regrowth*
1. *Frilled only*		4	42	0	4	4	1
2. *Frilled, 2,4,5-T*	0·5%	7	95	9	10	10	0
3. *ester in oil*	1·5%	8	95	9	10	10	0
4.	4·5%	8	100	10	10	10	0
5. *No frill, 2,4,5-T*	0·5%	3	39	1	2	4	1
6. *ester in oil*	1·5%	4	31	0	1	2	1
7.	4·5%	2	60	1	5	5	2
8. *Frilled, 2,4-D*	0·5%	7	82	5	8	9	1
9. *ester in oil*	1·5%	5	87	6	9	9	0
10.	4·5%	5	72	5	7	7	2
11. *Frilled, 2,4,5-T*	0·5%	3	33	0	2	2	1
12. *ester in water*	1·5%	3	29	0	3	3	1
13.	4·5%	0	32	0	4	4	2
14. *Frilled, 2,4,5-T, ester*	0·5%	1	34	0	6	7	0
15. *in water +0·5%*	1·5%	1	39	1	6	7	2
16. *aminotriazole*	4·5%	0	39	0	5	5	0

No. of trees/treatment	10
Volume of spray/tree	200 *ml*
Mean basal diameter	8·5 *in.*
No. of trees/acre	100
Volume of spray/acre	4·5 *gall*
Chemical/acre at 0·5, 1·5 and 4·5 per cent	0·22 0·7 *and* 2·0 *lb*

The first observation was made 2½ months after spraying when the trees were coming into leaf. No treatment completely prevented leaf development but, with several treatments, especially 2,4,5-T and 2,4-D in oil applied to frills, the majority of leaves fell before they had completely expanded and no further leaves were produced. With all concentrations of 2,4,5-T the trees were virtually leafless after 6½ months and all were dead after 14 months. By this time the dead trunks were heavily infested with wood-boring larvae, much of the bark had split and fallen away and many of the upper branches had fallen off. 2,4-D also killed the majority of the trees though its effects developed more slowly and were somewhat less complete. Without frilling on the other hand, 2,4,5-T was considerably less effective and, even with the highest concentration, only half of the trees died. The emulsions of 2,4,5-T in water were no more effective than frilling alone but there is evidence that the addition of 0·5 per cent aminotriazole to the emulsions increased their toxicity to some extent. It will be noted that frilling alone was sufficient to kill a number of trees and as no particular

attempt was made to ensure that the frills completely severed the bark it is evident that *A. nigrescens* is highly susceptible to ring-barking.

Only a small proportion of the treated trees produced regrowth (9 per cent of the total) although felled trees in the same area regenerated vigorously from the stumps. No regrowth appeared on any of the trees treated with 2,4,5-T in oil applied to frills but one or two trees in each group receiving the other treatments grew new shoots.

The results of this trial suggest that *A. nigrescens*, like the smaller species referred to earlier, is susceptible to basal spraying with low concentrations of 2,4,5-T in oil. With this species, however, the hard bark does not appear to be easily penetrated by the chemical and frilling is essential if a high degree of kill is to be obtained. As with the other species there is evidence that 2,4-D acts more slowly than 2,4,5-T, does not give quite such a high final kill and is less effective in preventing regeneration.

A. nigrescens is also similar to *A. hebecladoides* in that arboricides are more effective when applied to standing trees than to stumps which have been allowed to regenerate. In a trial on stumps bearing 18-month old regrowth foliage sprays of 2,4,5-T ester in water were ineffective. It was impracticable to apply oil-based sprays to the original stumps without first cutting back the regrowth. When this was done moderate kills of the stumps were obtained with 0·5, 1·0 and 2·0 per cent but the treatments were considerably less effective than similar treatments applied to standing trees.

(*2*) *Acacia tortilis* (*A. spirocarpa*)—This species is one of the most widespread of the large flat-topped Acacias and is an important constituent of the habitat of several tsetse species. It is susceptible to ring-barking but this operation is laborious and time-consuming and a trial to test the effects of 2,4,5-T was started in May 1955, at the end of the long rains period when some trees were starting to lose their leaves. The area selected was occupied by mature trees up to 50 ft high and groups of 20 trees were treated with three concentrations of 2,4,5-T in oil applied to frilled and unfrilled trunks. The treatments were applied by means of a paint-brush and the results are shown in *Table 3*.

After 7 months, during which time the area remained very dry, many of the smaller trees already appeared to be dead or dying. With the dead trees the bark had dried up and was starting to come away from the underlying wood, and the holes of wood-boring insect larvae were apparent. With a number of trees which had not yet reached this stage gum was exuding through the bark and the bark itself was seen to be discoloured on cutting. Such trees were dead by the time of the final observation. It will be seen from the table that the final kills were high with all concentrations and that treatment without frilling gave nearly as high percentage kills as were obtained with frilling. The data suggest that the lower concentrations of 2,4,5-T have been more effective than the higher but it is thought that this is mainly due to the fact that the plots receiving the higher rates contained a greater proportion of very large trees some of which were still alive 21 months after treatment. There was no evidence of basal regeneration from any of the trees killed by treatment.

(*3*) *Acacia senegal*—A trial on large trees 30 to 40 ft high, which started in November 1954 at the beginning of the short rains when the trees were

coming into leaf, showed that 2,4,5-T ester in oil at 1·0 and 3·0 per cent applied to frilled trunks was also effective in killing *A. senegal*. A few branches on some trees retained their foliage for up to 2 years before dying, but in 3 years the majority of the trees had fallen and there was no regeneration.

On this species 2,4,5-T at a concentration of 12 per cent in oil was effective when applied in holes bored at intervals of approximately 10 in. round the trunk. Ammonium sulphamate crystals applied in the same way, however, were ineffective although 0·5 lb was used for each tree.

Table 3. The effects of various concentrations of 2,4,5-T ester applied to Acacia tortilis *with and without preliminary frilling*

Months after treatment		7	21
Treatment		*Per cent dead*	*Per cent dead*
1. *Frilled, 2,4,5-T*	2·5%	45	85
2. *ester in oil*	1·2%	75	95
3.	0·6%	80	100
4. *Not frilled,*	2·5%	30	65
5. *2,4,5-T ester in oil*	1·2%	50	95
6.	0·6%	40	95
No. of trees/treatment		20	
Volume of solution/tree		ca. 550 *ml*	
Mean basal diameter		ca. 21 *in.*	
Estimated trees/acre		10	
Volume of solution/acre		1·2 *gall*	
Chemical/acre		0·3, 0·15 *and* 0·075 *lb*	

(c) *Climbing species*

Acacia pennata—As mentioned earlier, *A. pennata* is widespread throughout East Africa and occurs in a number of different bush communities. It differs from the majority of the other species in that it has no main stem but consists of a mass of thorny shoots arising from the root crown. Regeneration from the root crown is very rapid after cutting or burning and, although repeated burning keeps it under control, the root crowns are not killed and as soon as burning is discontinued further growth occurs.

A series of trials on *A. pennata* was started in the Machakos district of Kenya in June 1956 at the beginning of the dry season. Esters of 2,4-D and 2,4,5-T in diesel oil were tested in various ways as shown in *Table 4*.

In the first trial the two chemicals were compared at concentrations of 0·5 and 1·0 per cent applied to the base of uncut stems in a thicket 10 to 12 ft high. Approximately 150 ml of solution was applied to each plant bearing an average of 6 to 8 stems but much of the liquid failed to hit the thin stems and was deposited on the ground. It was thought that this deposit of chemical might have an effect on emerging regrowth and a 2,4-D formulation containing pentachlorophenol, a chemical which might be expected to increase the persistence of 2,4-D in the soil, was included in the trial in an attempt to increase this effect.

All treatments brought about almost complete defoliation in a few weeks and after 5 months, as shown in the table, the majority of the old shoots

were still leafless. Many, however, had produced new shoots up to 2 ft high from the base and after 19 months practically all the treated plants were regenerating. Only with 2,4,5-T at 1·0 per cent were a small number dead. At this time the treated area of thicket was somewhat more open than before spraying. The new shoots were growing very rapidly, however, and it was evident that the thicket would soon regain its normal density.

In the second trial an area of thicket was cleared and the chemicals were applied to freshly cut stumps. With stump application it was possible to obtain thorough wetting of the stems with lower volumes than where uncut stumps were treated, and 50 ml was sufficient to give complete coverage. A higher volume of 150 ml was also tested in the hope that the liquid running off the stems might reach the bud zone below ground.

Table 4. The effects of 2,4-D and 2,4,5-T esters in diesel oil applied to various types of growth of Acacia pennata

Months after treatment				5			19
Treatment			*No. sprayed*	*Per cent leafless*	*Per cent minus regeneration*	*Per cent of branches dead*	*Per cent minus regeneration*
Application to base of stems							
1. *2,4-D*	*170 ml*	0·5%	12	67	42	30	0
2. *2,4-D*	*140 ml*	1·0%	8	100	25	50	0
3. *2,4,5-T*	*140 ml*	0·5%	6	83	17	50	0
4. *2,4,5-T*	*130 ml*	1·0%	20	95	70	65	20
5. *2,4-D+*	*160 ml*	0·5%	17	100	47	40	0
6. *1% PCP*	*170 ml*	1·0%	12	91	0	70	0
			No. sprayed	*Mean height regeneration in.*	*Per cent minus regeneration*	*Mean height regeneration ft*	*Per cent minus regeneration*
Application to cut stems							
1. *Control*			10	21·0	0	8·0	0
2. *2,4-D*	*50 ml*	1·0%	10	1·2	30	4·1	0
3. *2,4-D*	*150 ml*	0·33%	10	1·5	20	4·2	0
4. *2,4,5-T*	*50 ml*	1·0%	10	1·0	50	3·9	0
5. *2,4,5-T*	*150 ml*	0·33%	10	0·7	80	4·8	0
6. *2,4-D+*	*50 ml*	1·0%	10	0·8	60	3·4	0
7. *1% PCP*	*150 ml*	0·33%	10	4·9	30	4·9	0
			No. sprayed	*No. living*	*Per cent reduction*	*No. living*	*Per cent reduction*
Application to slashed regeneration							
1. *Control*			22	34	0	20	9
2. *2,4-D*	*50 ml*	1·0%	11	6	45	6	45
3. *2,4-D*	*50 ml*	2·0%	36	24	33	16	46
4. *2,4,5-T*	*50 ml*	1·0%	73	10	86	45	38
5. *2,4,5-T*	*50 ml*	2·0%	14	1	93	1	93
6. *2,4,5-T*	*100 ml*	0·5%	25	0	100	3	88
7. *2,4,5-T*	*100 ml*	1·0%	27	2	93	8	70
8. *2,4-D+*	*50 ml*	1·0%	42	50	0	20	52
9. *1% PCP*	*50 ml*	2·0%	32	22	31	15	53
Estimated number/acre				1000			
Volume of spray/acre at 50 ml per plant				11 *gall*			
Chemical/acre at 1·0%				1·1 *lb*			

The table shows, however, that there was little difference between the two volumes. All treatments killed the original stumps but none prevented the eventual appearance of regrowth. Varying proportions of stumps were starting to produce new shoots after 5 months, the number being less with the higher volume of 2,4,5-T, but after 19 months all treated stumps were growing vigorously. The final effect of the sprays was to reduce regrowth to about half of that appearing from the control stumps.

The third trial was carried out on an area which had been cleared and burnt a few months previously and where copious regrowth up to 5 ft high had taken place. The regeneration was cut back to ground level and the sprays applied to the stumps. The treatments shown in the table were applied to the stumps on 1/50 acre plots and the number counted at intervals. Although satisfactory counts of *A. pennata* are impossible without marking individual groups of shoots, the results of this trial suggest that 2,4,5-T was more effective than 2,4-D. It is also evident that the 2,4-D–PCP mixture was not appreciably more effective than 2,4-D alone. There was no clear difference between concentrations, however, or between the two rates of application of 2,4,5-T.

CONCLUSIONS AND DISCUSSION

From the present series of trials it can be concluded that the above-ground portions of *Acacia* species are relatively susceptible to treatment with arboricides of the growth-regulator type and that, for species with little ability to produce regrowth from below ground, effective control can be achieved with small amounts of chemical. In general 2,4,5-T appears to be more effective than 2,4-D and the difference between the two chemicals is more marked on those species which produce regeneration from below ground. With the exception of *A. pennata* the most effective type of treatment is an oil-based spray of an ester formulation applied to the base of the trunk. For larger species, especially those with a hard bark such as *A. nigrescens*, preliminary frilling of the trunk appears to be necessary. For smaller trees, such as *A. hebecladoides* and *A. zanzibarica*, frilling does not appear to be essential and there is a suggestion that less regeneration occurs when the bark is uncut. Water-based sprays have not been found effective for basal bark treatment.

With oil-based sprays of 2,4,5-T the results suggest that there is rarely much advantage in using concentrations above 1·0 to 2·0 per cent and 0·5 per cent has been sufficient in many cases. In the present series of trials rates of application of 20 to 30 ml per inch diameter of trunk have been used and adequate wetting of the bark cannot be obtained with rates much lower than this.

Although the tree species of Acacia are most economically killed by treatments applied to the base of standing trees, 2,4,5-T can also be used to prevent regeneration from stumps. Such treatments are best applied to freshly cut stumps and, in cases where new shoots have already been produced, it appears to be necessary to cut these shoots back and to apply the spray to the original stumps.

These conclusions are in general agreement with the results of a number of other trials with arboricides on Acacia species in East Africa. In Uganda,

for instance, effective control of the small trees *A. mellifera*, *A. seyal* var. *fistula*, *A. nubica* and *A. subalata*, has been obtained with basal bark sprays of 0·5 and 1·0 per cent 2,4,5-T in diesel oil (Uganda, 1956) and a mixture of 1·0 per cent 2,4-D and 0·5 per cent 2,4,5-T in oil has given good results on *A. hebecladoides* both as a basal bark spray and as a stump treatment (HARKER, 1957). In the Sudan on the other hand, LEA (1957) obtained a considerably higher kill of *A. seyal* by ring-barking than by treatment with 2·0 per cent 2,4,5-T. *A. hockii*, a small shrubby species, has been found very difficult to control. As with *A. pennata*, although the above-ground parts are readily killed, a large proportion of the plants produce regrowth. Basal sprays to uncut stems and overall sprays have been found relatively ineffective and uneconomical on this species. Stump sprays have given higher kills and it is considered that a combination of burning, cutting and spraying offers the best chance of control (HARKER, 1957).

A. pennata appears to possess the greatest powers of regeneration of all the Acacia species and, for this reason, is the most difficult to eradicate. In the present trials 2,4,5-T in oil applied to slashed regrowth gave a moderate degree of control for 19 months and it is probable that several applications would kill the majority of the root crowns. Such treatment would be extremely expensive, however, and repeated application of 2,4,5-T is only likely to be economical if water-based sprays can be used. Recent trials in Kenya suggest that emulsions of 2,4,5-T in water have much the same degree of effect on *A. pennata* as oil solutions (Kenya, 1957) and, at present, such emulsions appear to offer the best hope of economical control.

To kill tree species incapable of producing regrowth from below ground level it is not necessary for an arboricide chemical applied to the base of the trunk to be translocated far in a downward direction. For those species which do regenerate, however, downward translocation is necessary for the chemical to be effective and the main reason for the limited effectiveness of 2,4,5-T and 2,4-D on such species as *A. pennata* and *A. hockii* is that the chemicals are not moved far enough into the roots from the point of application. It has been shown by LEONARD and CRAFTS (1956) that the movement of 2,4-D in woody plants parallels that of food materials, being mainly in an upward direction in spring and early summer and downwards in autumn. It would therefore be expected that the time of year at which arboricide treatments are applied would have a considerable influence on their effectiveness in preventing regeneration.

At present the amount of information available on the relative effectiveness of arboricides applied at different seasons on tropical trees is very limited. On species which do not regenerate from below ground, spraying has been effective both during the rains and during the dry season. With *A. hebecladoides*, however, treatments applied when the trees were actively growing gave better results than when they were entering a dormant phase during the dry season. This observation agrees with findings in Brazil that mixed stands of bush, including Acacia species, are more effectively controlled by aerial application of 2,4,5-T when sprayed during a period of new leaf growth at the beginning of the rains than when the treatment is applied during the dry season (QUINN *et al.*, 1956). These authors also emphasize the point, probably as important in East Africa as in Brazil, that, when

woody species are killed for pasture improvement, treatment early in the rainy season enables the grasses to benefit to the maximum extent from the removal of the bush and to provide the maximum competition against regrowth.

SUMMARY

A series of experiments is described in which the chemicals 2,4-D and 2,4,5-T have been tested on a number of species of Acacia. In most of the trials ester formulations of these chemicals have been used dissolved in diesel oil and applied as basal bark sprays. The results are summarized in *Table 5* which, for purposes of comparison, also indicates the results obtained in trials carried out by other workers in East Africa.

The results of the trials suggest that the above-ground parts of most Acacia species can be killed by arboricide treatment. With the larger species tested little or no regeneration occurs. With some of the smaller species,

Table 5. Summary of the effects of 2,4,5-T on East African Acacia species

Species	*Type of regrowth after cutting (above or below ground)*	*Response to basal spray of 2,4,5-T ester in oil*	*Frilled or not frilled*	*Other observations*	*Source of information*
Large trees					
A. nigrescens	*Above*	*Complete kill with 0·5%*	*Frilled*	*Killed by ring-barking*	*Present trials*
A. senegal	*Above*	*Most killed with 1·0%*	*Frilled*	*Killed by 12% in bore-holes*	*Present trials*
A. tortilis	*Above*	*Complete kill with 0·6%*	*Frilled*	*Most killed without frilling*	*Present trials*
Small trees					
A. hebecladoides	*Above and below*	*Most killed with 1·0%*	*Not frilled*	*Regrowth after stumping killed by CMU*	*Present trials*
A. zanzibarica	*Above ? below*	*Most killed with 1·0%*	*Not frilled*	—	*Present trials*
A. mellifera	*Above ? below*	*Killed with 0·5%*	*Not frilled*	—	*Uganda, 1956*
A. seyal *var.* fistula	*Above ? below*	*Killed with 0·5%*	*Not frilled*	—	*Uganda, 1956*
A. subalata	*Above ? below*	*Killed with 1·0%*	*Not frilled*	—	*Uganda, 1956*
A. lahai (*stumps*)	*Above ? below*	*Good kill with 1·0%*	—	—	*Kenya, 1953*
Shrubs					
A. nubica	*Above ? below*	*Killed with 1·0%*	*Not frilled*	—	*Uganda, 1956*
A. hockii	*Mostly below*	*Moderate kill with 1·5% 2,4-D–2,4,5-T mixture*	*Not frilled*	—	HARKER, *1957*
A. pennata (*regrowth*)	*Mostly below*	*Moderate kill with 0·5%*	—	*Repeated application probably needed for adequate control*	*Present trials*

such as *A. hebecladoides*, a greater degree of regeneration can occur but it is very considerably reduced by the more effective treatments. *A. pennata*, on the other hand, regenerates very vigorously and it does not appear that satisfactory control can be achieved with a single oil-based spray. *A. hockii* is reported as difficult to control for the same reason.

In general 2,4,5-T appears to be more effective on Acacias than 2,4-D. When applied in oil as a basal bark spray, increases in concentration above 1·0 to 2·0 per cent give little additional effect and 0·5 per cent is frequently sufficient. With the smaller trees, frilling the bark does not appear to be necessary but with some of the larger trees having a hard impermeable bark, such as *A. nigrescens*, it greatly increases the effectiveness of spraying.

There is evidence that non-regenerating species can be killed by basal sprays applied at any time of year but that, where regrowth occurs, the best results are obtained by application during a period of active growth.

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High Yields in Cacao Field Experiments and their Significance in Future Cacao Research

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Cacao field experiments conducted by the Soils Department of the Regional Research Centre, Imperial College of Tropical Agriculture, Trinidad, have been previously described (Havord, 1953a and 1953b; Havord *et al.*, 1954, 1955a and 1955b). The soil on which the experiments are sited is an imperfectly drained sandy loam alluvium of pH varying from 6·4 in the top six inches to 5·8 at 2 ft; low in total nitrogen (0·17 per cent in the top six inches), available potash (74 p.p.m.) and phosphate (19 p.p.m.); and subject to a rainfall of about 78 inches mostly distributed over the months of May to December. A slight dry spell is frequently experienced during September or October.

Experimental cacao yields on this soil are now available for four successive years and the general treatment effects are repeatedly under review. Certain aspects of these yields, in particular phenomenally high yields of restricted parts of the experiments, have not, however, received attention hitherto. A study of these high yields and their associated environmental factors is providing valuable emphasis to our future research.

Table 1 gives the maximum yields obtained in parts of the field experiments during the 1956–7 cropping season together with additional relevant information.

In Experiment I an overall average yield of 1 198 lb dry cacao per acre was obtained. Optimum yield was associated with the absence of shade, applications of ammonium sulphate and superphosphate and with close spacing. Early work on seedling cacao (Freeman, 1929) suggests that yield differences due to spacing may diminish as the cacao gets older. In addition, split applications (half in May and half in September) of nitrogen fertilizer to unshaded close-spaced trees are capable of inducing yields of over 1 400 lb dry cacao per acre. *Table 1*, however, shows yields which are in excess of this value by 400 to 500 lb.

In Experiment II average yields of 1 200 lb/acre were obtained with ICS 1 clones. *Table 1*, however, indicates that certain plots yielded on an acreage basis between 600 and 1 200 lb in excess of the average yield. Similarly Experiments III and IV provided maximum yields in strong contrast to experimental averages. From this diversity of evidence there appears to be a pointer towards unknown factors functional in boosting cacao yields to an extent as great as and in fact in some cases even greater than those experimentally imposed.

Table 1

Experiment	*Type of shade tree*	*Clone*	*Planting distance ft*	*Treatment*	*Yield (lb dry cacao/acre)*	*No. of trees*
I						
Shade, spacing and fertilizer	*None*	*ICS 1*	8 × 8	*NP*	1 943	36
	None	*ICS 1*	12 × 12	*NK*	1 898	16
	None	*ICS 1*	8 × 8	*PK*	1 839	36
	None	*ICS 1*	8 × 8	*NPK*	1 817	72
	None	*ICS 1*	8 × 8	*None*	1 807	36
	Immortelle	*ICS 1*	12 × 12	*PK*	1 801	16
II						
Legume v non legume	*Immortelle*	*ICS 1*	12 × 12	*NPK*	2 503	4
	Immortelle	*ICS 1*	12 × 12	*PK*	2 421	8
	Theobroma bi-color	*ICS 1*	12 × 12	*NPK*	1 990	4
	Immortelle	*ICS 8*	12 × 12	*NPK*	1 885	4
III						
Spacing, mulching and trenching	*None*	*ICS 6*	7·2 × 7·2	*Grass mulch*	2 114	16
	None	*ICS 60*	9 × 9	*Bagasse*	2 064	9
	None	*ICS 8*	9 × 9	*Grass mulch*	2 016	9
IV						
Tillage and manures	*Immortelle*	*ICS 1*	12 × 12	*Grass mulch*	2 197	8
	Immortelle	*ICS 1*	12 × 12	*Pen manure*	2 037	8
	Immortelle	*ICS 1*	12 × 12	*Grass mulch*	1 818	8

In what direction do we turn for an explanation of this problem ? So far our studies suggest two factors either or both of which may contribute toward the production of phenomenally high cacao yields. In the first place there is clearly a strong tendency for our 1950 plantings to stand out as heavy bearing. A similar year was 1940. The effect is clearly seen in *Table 2* which contrasts the yields from 1940 and 1950 plantings with those of previous years.

Table 2. Yields (lb dry cacao/acre) from ICS 1 clonal cacao, planted 12 ft × 12 ft, growing under immortelle shade

Year of planting	*Cropping season*			*3-year mean*
	1954–5	*1955–6*	*1956–7*	
1949	866	824	1 117	936
1950	1 329	1 521	1 802	1 551
	1948–9	*1949–50*	*1950–1*	
1937	478	1 052	1 376	969
1938	608	954	1 291	951
1939	680	960	1 339	993
1940	854	1 211	1 656	1 240

This effect is not restricted to particular areas of the cacao experiments. So far as is known supply of plants and general field management methods were constant. It appears fairly certain that some quality associated with climatic conditions around planting time proved so favourable to cacao growth that the benefits which accrued were never lost.

In the second place the high yields of *Table 1* accentuate an effect that has long been recognized in Trinidad—the variation in yields of cacao

trees within experimental treatments. Unquestionably part of this variation is attributable to variations in the age of plants. Even with one planting date the clonal cuttings necessary to stock an experimental site may involve an age variation of more than one year. This is often a consequence of practical difficulties in the propagator and of natural hazards during establishment. Should the influence of a favourable year as in 1940 or 1950 also intervene within the initial establishment years, the final experimental variations arising from such causes may indeed be large.

Appreciable variability is also induced, however, by the effect illustrated in *Figure 1*, showing mean cacao yields over three cropping seasons plotted against mean girths at ground level, of the trees at 3·5 years of age. The data used came from 68 plots planted at a spacing of 12 ft × 12 ft in 1949 and 1950 with immortelle shade. The correlation coefficient ($r = 0{\cdot}810$) of this relationship is very highly significant (at $P = 0{\cdot}001$, $r = 0{\cdot}380$).

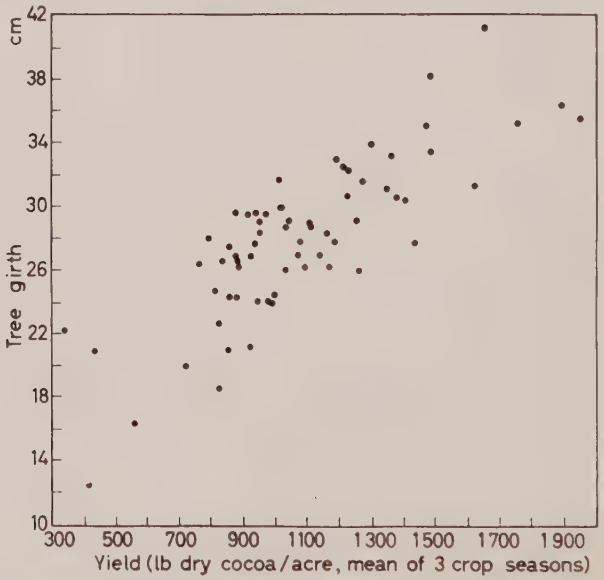

Figure 1. Cacao tree size/yield correlation ($r = 0{\cdot}810$: *for* $P = 0{\cdot}001$, $r = 0{\cdot}380$)

The cacao yields involved in this correlation have been strongly conditioned by factors which were clearly present and operative during the early establishment of the plants and which are reflected in the girth measurements of these plants at 3·5 years. Yield variability due to variations in tree size are clearly considerable. It is the authors' considered opinion that the combined factors given in this paper satisfactorily explain the erratic yielding behaviour of cacao which has been so frequently observed in past Trinidad cacao experiments.

A conclusion of the greatest practical importance can be drawn from *Figure 1*. Cocoa plants which are well managed and fed and which thereby produce big plants in about three years will ultimately produce high cocoa yields. It is probably true also to conclude that the greatest chance of

achieving this end is obtained by starting with the biggest plants. There must follow in addition an uneventful growing period during which time the young plants must not suffer any form of growth check, since this would lead to a reduction in size and also in ultimate yields. All this in fact puts great emphasis on the role of good management if high yields are to be obtained.

It is of particular research interest to find that early girth measurements so closely reflect later tree performance, and the technique is of the greatest value in the study of tree crops in general. Pot tests provide a relatively quick study procedure for annual plants but are unsuited to perennials for obvious reasons. The use of yields on the other hand in the study of perennials necessarily involves a long waiting period before sufficient data become available. Girth measurements clearly offer a means of speeding up the work.

The importance to cacao research arising from *Figure 1* is the emphasis it gives to those factors that produce optimum conditions of plant establishment and early growth. It may be that these ' early factors ' will prove later to be those limiting maximum response to environmental variants such as shade, fertilizers and spacing imposed in the past; and maximum response to the latter factors following removal of the limitations imposed by deficiencies in establishment may indeed lead to phenomenally high yields. The maximum yields in our experiments quoted in this paper show how distant we are from establishing a ceiling to the productivity of the cocoa plant. Our future research emphasis in this respect will certainly be applied to the factors that control the early health and growth of the cocoa tree.

SUMMARY

Some very high cacao yields in Trinidad field experiments are quoted. These high yields are only displayed by a restricted number of trees within the experiments.

Evidence is provided for two factors which explain this phenomenon. The first, a climatic factor, is clearly at an optimum in certain years. The second, initial plant size, emphasizes the role of good management in attaining high yields of cacao. This factor together with variability in establishment factors, satisfactorily explains in the authors' opinion the erratic yielding behaviour in past Trinidad cacao experiments.

The need for research emphasis on the early phases of cacao establishment is accented. In this respect girth measurements are a valuable method of hastening the rate of study on perennials.

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Disease Resistance in Field Trials With Cacao at Hacienda Clementina, Ecuador

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At Hacienda Clementina, situated north of Guayaquil near the town of Babahoyo, selection of cacao clones was started in 1946. At this time some of the older plantations were still of the Nacional type, but new introductions from Venezuela had been carried out (Fowler and López, 1949, p 12), and from a few trees of these introductions, selected for yield as well as disease resistance (Pound, 1938, p 18), new cacao fields had been established. Some of these fields were considered to be well suited for further selection, the material being highly variable in morphology as well as in degree of disease incidence.

At Clementina, just as in other parts of Ecuador, the cacao plantations had been largely destroyed by attacks of the Witches' Broom disease, *Marasmius perniciosus*, and *Monilia* attacks on the pods reduced the yield still more. Stimulated by the successful work carried out by Cheesman (1946) and others in Trinidad, the present writer suggested to the Swedish board of the hacienda that clonal propagation and selection should be carried out. About 200 mother trees were marked, and records from them were gathered during a 3-year period. In the meantime, thanks to the courtesy of the Department of Agriculture and the authorities of the Imperial College of Tropical Agriculture, a total of 64 cacao clones were introduced from Trinidad. Fifty five of these clones belong to the ICS series and 7 are clones collected by Dr F. J. Pound in the Upper Amazon region (1938, 1943).

Part of the imported material, our local selections and some other clones from Ecuador have been compared in field trials with regard to yield, disease resistance, reaction to spraying and fertilization. In the present note some results on disease resistance will be summarized. In the first place these results are derived from a special resistance trial, which was established at the beginning of 1952 in the middle of a severely infected ' cacao jungle ' area. In this area the three diseases Witches' Broom (WB), *Monilia* and *Phytophthora* are predominant, the most severe losses being caused by WB. Indeed, the WB infection in this trial is so severe that growth has been retarded and pod production poor. In 1956 and 1957, however, some data on pod infection could be gathered, otherwise the records from this trial are limited to the degree of floral and vegetative WB infection.

Supplementary data have been obtained from a yield trial situated in another field, more isolated from the infected cacao jungle. Besides yield data this trial has also given us information about the degree of pod infection

of the various clones. A full account of this work is given by MÜNTZING (1958).

Altogether 32 ICS clones and 18 other clones were studied, the latter category chiefly representing the local selections at Clementina and some clones from the Upper Amazon region. A wide range of variation was observed with regard to WB resistance (*Table 1*). On average the ICS clones

Table 1. Grading list, resistance trial. Total WB (fan and cushion brooms). Data from 1954 to 1956

Clone	Grading number for resistance				Resistance	Clone	Grading number for resistance				Resistance
	1954	1955	1956	Average			1954	1955	1956	Average	
SCA 6	1	1	1	1	*Excellent*	*SI 53*	25·5	28·5	29	26	*Intermediate*
SCA 12	4	2	2	2		*ICS 53*	12	33	40	27–28	
P 12 A	2	3	3·5	3		*ICS 84*	27	23	35	27–28	
ICS 89	5	8	3·5	4		*ICS 85*	20·5	28·5	41	29	
ICS 32	3	5	15	5							
ICS 100	7	6	13·5	6		*ICS 22*	25·5	25	42	30	*Poor*
CG 28	6	4	18	7		*ICS 60*	31	38	24	31	
SI 95	8·5	17	6	8		*S 62*	38	34	26·5	32	
ICS 80	11	14	7·5	9		*ICS 87*	34·5	32	35	33	
						ICS 48	42	27	33	34	
IMC 67	19	10·5	5	10	*Good*	*ICS 8*	36	44	23	35	
CG 10	17·5	10·5	7·5	11		*WB 2*	28	31	44·5	36	
SI 21	10	15·5	10·5	12		*ICS 40*	46	36	25	37	
SI 234	8·5	9	19·5	13		*ICS 28*	32	40	37·5	38	
SI 55	14	12	16	14		*RT 18*	37	35	39	39	
T 119	16	18	13·5	15							
ICS 61	24	19	9	16–17		*CG 17*	43	40	35	40	*Very poor*
ICS 74	20·5	7	26·5	16–17		*ICS 6*	40	48	31	41	
ICS 62	22	21	17	18		*ICS 35*	39	49	32	42–43	
SI 148	23	20	21	19		*ICS 46*	46	46	28	42–43	
						CG 5	34·5	43	47	44	
CG 12	29	24	12	20–21	*Intermediate*	*ICS 49*	41	42	44·5	45	
CG 52	30	15·5	19·5	20–21		*ICS 91*	46	37	48·5	46	
ICS 95	15	13	37·5	22–23		*ICS 47*	50	39	46	47	
CG 1	33	22	10·5	22–23		*ICS 39*	49	45	43	48	
ICS 41	13	26	30	24		*ICS 78*	44	47	50	49	
ICS 1	17·5	30	22	25		*ICS 43*	48	50	48·5	50	

were less resistant than the Clementina clones, but ICS 89, 32, 100 and 80 had an excellent resistance in contrast to ICS 49, 91, 47, 39, 78 and 43 which were very poor in this respect. The best resistance was shown by the well-known clones SCA 6, SCA 12 and P 12 A.

A high degree of positive correlation was observed for the values of total WB infection (fan brooms and cushion brooms) between the three years of observation. A high positive correlation between frequency of vegetative and floral WB was also established. No correlation between vegetative vigour and degree of WB infection could be found.

Different degrees of general pod infection (chiefly WB but also other diseases such as *Monilia* and *Phytophthora*) are characteristic of different clones. This was established in both sets of available data, the figures from the resistance trial showing positive correlation with those from the yield trial.

On average, pod resistance was better in the Clementina clones than in the ICS clones, this difference probably being the result of successful

selection for disease resistance among the Clementina clones as well as a better adaptation to the local climate and environment. The Upper Amazonian clones SCA 6 and SCA 12, which have excellent resistance to fan and cushion brooms, have also a fairly good, though far from absolute, pod resistance. P 12 A is poor in this respect. The average degree of pod infection may be very different in different years, as revealed by a comparison between data for 1955 and 1956.

Clones with a good pod production have, on an average, healthier pods than clones producing a small number of pods. The most probable explanation of this fact is that in susceptible clones such a high proportion of the young cherelles are killed that the production of mature pods is decreased.

A positive correlation between total WB (fan and cushion brooms) and general pod infection was slightly indicated but not statistically significant. Pod disease resistance is evidently largely independent of resistance to floral and vegetative WB.

Disease avoidance rather than disease resistance of the pods was demonstrated to occur among the ICS clones, some clones producing the great majority of the pods at the end of the dry season when infection is low. Disease avoidance was less clear with regard to the clones from Ecuador and the Upper Amazon region, which largely represent selections for increased resistance. Specific pod resistance rather than disease avoidance also occurs among the ICS clones.

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A New Approach to the Fermentation of West African Amelonado Cocoa

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Recent experimental work at the West African Cocoa Research Institute (Rohan, 1955 to 1958c, inclusive) has been designed to provide information on the conditions, chemical and physical, governing the fermentation of Amelonado cocoa. Results from a large number of heap fermentations have shown that there is quite a significant difference between the rates at which the changes, associated with fermentation, take place in the centre of a heap and at the surface. There is, in fact, a sufficient body of evidence to show that the beans in the surface layer may die within twenty four hours and that, within six to twelve hours of death, they may be removed from the heap and dried to give an acceptable product (Rohan, 1957b). Further studies in the rapid fermentation of Amelonado cocoa arose from this work and it was clear that large scale treatment in a reduced time would be possible. This paper describes the application of previously obtained results on a larger scale and provides a technique for the efficient fermentation of West African Amelonado cocoa in two to three days with a minimum of handling. Comparative costs are given for this new method and the traditional methods of fermentation.

DISCUSSION AND RESULTS

Existing methods of fermentation

The bulk of Ghana cocoa is grown by peasant farmers who ferment their crop in heaps on the ground. These heaps, which vary in size considerably, are prepared by placing the contents of the cocoa pods on a layer of plantain leaves and covering the heap with the same material. An alternative method employed in Ghana, but only to a limited extent, makes use of large boxes known as ' sweat-boxes '. In some areas the cocoa is fermented in baskets and the conditions of fermentation recommended for all these methods are six days treatment and mixing of the bean-mass after forty eight and ninety six hours. Mixing is done in the sweat-boxes by transferring from one box to another and, in heaps, by uncovering and mixing by hand or with wooden shovels.

New methods of fermentation

In the course of an investigation into the methods (Rohan, 1957b and 1958b) of fermentation it was found that the changes associated with fermentation appeared to occur more rapidly at the surface of fermenting heaps than at the centre. A detailed study of this surface effect showed that the beans in the surface layer of some four inches in a fermenting heap were killed within twenty four to thirty hours and that, if the beans were removed

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and dried six to twelve hours later, a good quality cocoa was obtained. It was clear that, if the surface effect could be isolated, it might be possible to ferment this cocoa, in bulk, in a much shorter time than previously used and that an increase in uniformity of product might be obtained. To reduce the depth of any given mass of fermenting cocoa to the order of four inches would increase its surface area considerably and introduce the possibility of considerable heat losses. It was thought possible that with suitable lagging, higher temperatures and sharper temperature rises could be obtained since G. R. Howat and G. A. R. Wood (private communication) observed a temperature of 45°C after 50 hours when cocoa was spread in thin layers some four to five inches in depth. A wooden frame was constructed, in *Chlorophora excelsa* timber, three feet square and eight inches deep with a slatted bottom. Wet beans were placed in this tray to a depth of four inches and covered with plantain leaves. Several experiments were made, using this equipment, and the mean temperature observed after 24 hours was 42°C. In some fermentations the temperature rose above this and the system was sufficiently successful to warrant further investigation (Rohan, 1957b).

Figure 1

Experiments in ' Dexion ' framework

A number of trays, four feet by three feet and four inches deep, with slatted bottoms, were made in *Chlorophora excelsa*. These trays were charged with 200 lb wet cocoa to a depth of four inches, covered with plantain leaves and stacked above each other in a rack constructed of Dexion (*Figure 1*). The space between the trays was varied between six and twelve inches and the distance from the bottom tray to the floor varied between six and thirty inches. Experiments were made in which the framework was completely

covered in sacking to reduce heat losses. In some experiments the 'sweatings' were allowed to drain through from one tray to the next in contrast to experiments in which each tray was drained separately. Temperature measurements were made in each tray one inch from the top, at the centre and at one inch from the bottom. At each level, measurements were made at twelve and four inches in from the sides. It was found that the temperature gradient down through any tray was insignificant and only the temperatures at the centre were recorded. It was also found that the distance separating the trays from each other and the distance of the bottom tray from the floor were not significant factors in this method of arrangement of the trays. *Figures 2* and *3* show the results obtained from two different racks of five

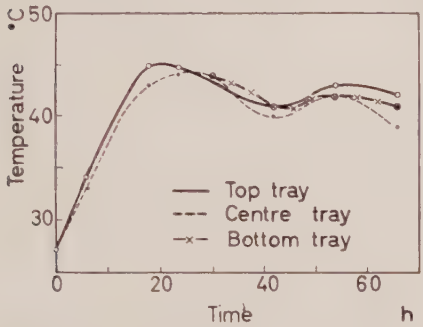

Figure 2. Five-tray stack on Dexion frame. Trays 12in. apart; each tray covered with plantain leaves. Cotyledon appearance: slate 3, deep purple 17, pale purple 63, brown 13. Quality: unacceptable

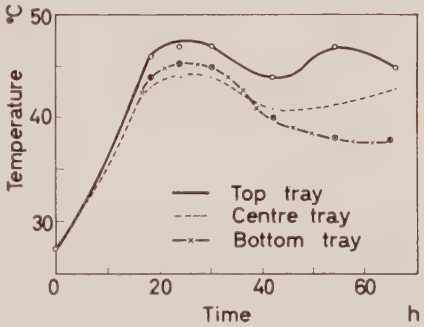

Figure 3. As Figure 2, but Dexion frame covered with sacking. Cotyledon appearance: slate 2, deep purple 16, pale purple 62, brown 10. Quality: acceptable

Figure 4

trays twelve inches apart with the lower tray fifteen inches from the floor. The effect of lagging the stack was to give slightly higher temperatures in the lower trays.

Experiments in stacks

Consistently good results were not obtained with the above systems and the trays were then filled with wet cocoa to a depth of four inches and stacked directly on top of each other (*Figure 4*), the top tray only being covered with plantain leaves and sacking. In this way the ' sweatings ' drained through the mass exactly as they do in sweat-boxes and in heaps with the important difference that aeration through the mass was increased by the separation of each four inch layer from that above by just a sufficient amount to permit air circulation. It was found that a close-fitting cover of sacking improved the temperature gradient in these stacks and *Figures 5* and *6* show the time/temperature curves of two typical examples. In *Figure 5* the stack was

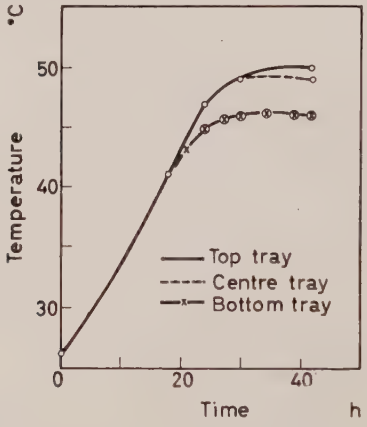

Figure 5. Five trays each containing 200 lb wet cocoa to a depth of four inches, stacked directly on top of each other with a close-fitting sacking over the stack. Cotyledon appearance: slate 0, deep purple 23, pale purple 50, brown 27. Quality: acceptable

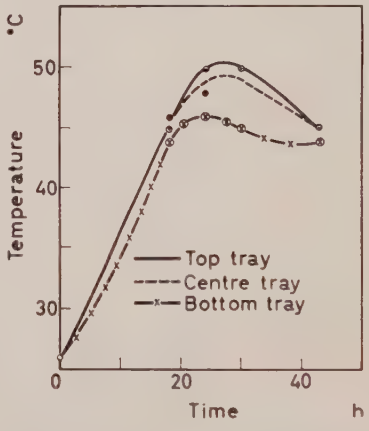

Figure 6. As Figure 5, but uncovered. Cotyledon appearance: slate 0, deep purple 21, pale purple 52, brown 27. Quality: acceptable

covered with a closely fitting sacking cover and in *Figure 6* the stack was uncovered apart from the top tray.

Fermentation in two-inch layers

Having established the feasibility of fermenting four-inch layers of cocoa it was intended that the fermented cocoa should be dried on the same trays in order to reduce handling costs to a minimum. It was found, however, to be impracticable to dry layers of this depth and experiments were carried out to determine whether it might be possible to ferment in two-inch layers and dry the cocoa in the same trays. *Figures 7* and *8* show the results obtained from fermenting two five-tray stacks, containing 100 lb of wet cocoa in each tray, to a depth of two inches. The results were unsatisfactory but it was established that a two-inch layer of wet cocoa could be dried properly on the trays described.

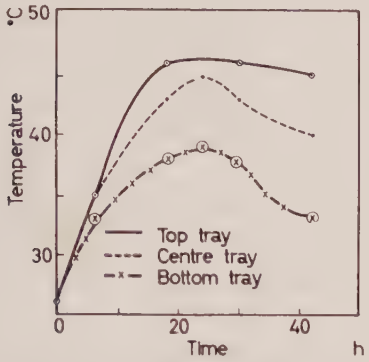

Figure 7. Five trays each containing 100 lb wet cocoa to a depth of two inches. Trays stacked directly on top of each other. Stack covered with close-fitting sacking jacket. Cotyledon appearance: slate 9, deep purple 17, pale purple 67, brown 13. Quality: unacceptable

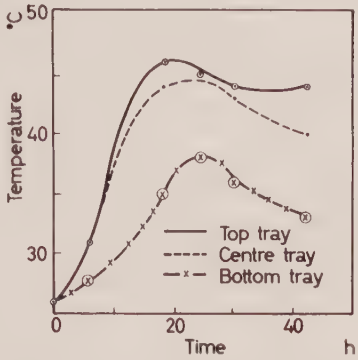

Figure 8. As Figure 7, but stack not covered. Cotyledon appearance: slate 5, deep purple 10, pale purple 55, brown 30. Quality: unacceptable

Divided trays with one half filled to four inches

Since it was desirable to ferment a four-inch layer and dry a two-inch layer the trays were fitted with removable partitions and 100 lb of wet cocoa charged to a depth of four inches in one half of each tray (*Figure 9*). The

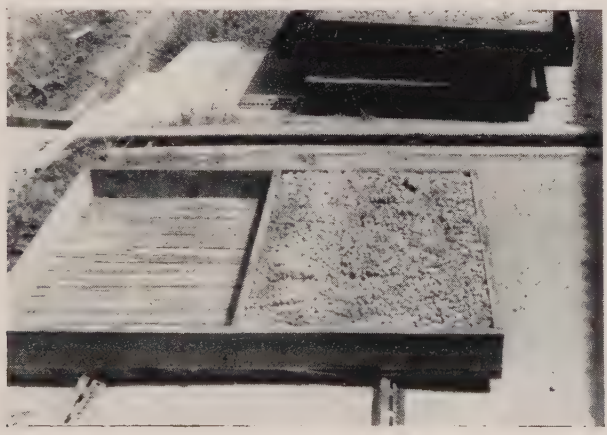

Figure 9

trays were stacked on top of each other in such a manner that the filled sections were directly above each other. *Figure 10* shows the results obtained from such a stack. Alternating the filled sections in the stack did not have any advantage, consequently the filled sections were placed above each other in all subsequent experiments. Experimental results indicated that if the close-fitting cover of sacking was put on after twenty four hours fermentation a better time/temperature curve was obtained.

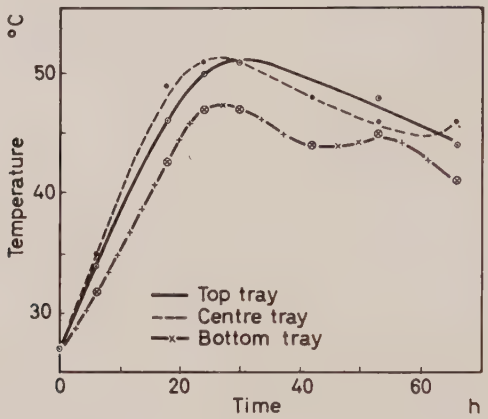

Figure 10. Five trays each containing 100 lb wet cocoa to a depth of four inches in one half. Filled sections directly above each other. Stack covered with close-fitting sacking jacket. Cotyledon appearance: slate 0, deep purple 32, pale purple 41, brown 27. Quality: acceptable

Fermentation in twelve-tray units

A number of successful experiments were made with five-tray stacks but it was considered more economical of space to attempt fermentation of larger quantities. Using the technique described above several twelve-tray units, containing 1 200 lb wet cocoa, were fermented and *Figure 11* shows

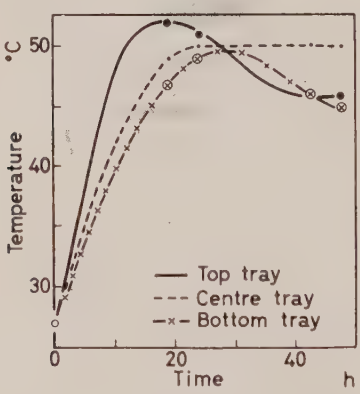

Figure 11. Twelve trays each containing 100 lb wet cocoa to a depth of four inches in one half. Filled sections directly above each other and stack covered with close-fitting sacking jacket. Cotyledon appearance: slate 1, deep purple 48, pale purple 28, brown 23. Quality: acceptable

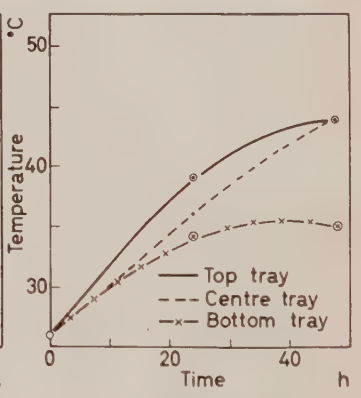

Figure 12. Initial 48 h in normal sweat-box fermentation

the results obtained in a typical run. Several tons of cocoa have been successfully fermented by this method and there is no doubt as to its efficiency. *Figure 12* shows the time/temperature curves in a normal sweat-box fermentation for comparison.

Period between harvesting the pods and breaking

Leaving the pods for some three days after harvesting gives a sharper rise in temperature and a higher maximum temperature than when the pods are broken shortly after harvesting. Reference to this phenomenon has already been made by HANCOCK (1949).

Relative merits of the different methods of fermentation

External appearance—The new method of fermentation described in this paper gives a bean of very clean external appearance and of an attractive reddish-brown colour. The shells are slightly heavier and not so brittle as in traditionally fermented cocoa. This could be an important quality during handling and transport.

Internal appearance—The product of these tray fermentations is, on the whole, of superior appearance to the cocoa produced in Ghana by the peasant farmer and compares very favourably with the normal W.A.C.R.I. sweat-box product.

Uniformity of product—The material obtained from the new method of fermentation is considerably more uniform both in bean size and external appearance than Grade 1 Ghana cocoa.

Bean size—The average bean weight obtained in experimental work on tray fermentation was 1·20 g which is greater than the normally accepted value for West African Amelonado. The beans were also more plump in appearance.

Cost of production—Several estimations of the labour costs involved were made for the normal methods of fermentation for comparison with the new technique. The actual costs were calculated after completion of pod breaking since other factors, e.g. harvesting and pod haulage, are outside the scope of this paper and should be common for all methods of fermentation. The results which were obtained are shown in *Table 1* and include the following operations:

(*1*) Weighing wet cocoa
(*2*) Loading fermenting vessel
(*3*) Mixing fermenting mass
(*4*) Discharging fermenting vessel and transferring to drying mats
(*5*) Mixing and sorting on drying trays
(*6*) Covering and uncovering beans during drying
(*7*) Bagging.

Table 1. Labour costs involved in fermenting and drying cocoa by various methods

Method of fermentation	*Cost of preparing one ton dry cocoa in man-hours*
(1) *Sweat-boxes in tiers. Fermented six days and turned after 48 and 96 h*	66
(2) *Sweat-boxes on level. Fermented six days and turned after 48 and 96 h*	67
(3) *Heap fermentation. Fermented six days and turned after 48 and 96 h*	58
(4) *Tray fermentation. Fermented two to three days and not turned*	50

It will be observed that the new technique results in a saving of labour of some 20 per cent and this in experimental work involving relatively small quantities.

Effect of ambient temperature

All experimental tray fermentations, with one exception, were carried out in a small shed with fine mesh sides and an iron and glass roof. The inside temperature in this building fluctuated between an average night minimum of 25°C and an average day maximum of 35°C. The graphs show that these variations in temperature were without pronounced effect on the time/temperature curves which were all comparatively smooth.

Drying

At the end of fermentation the beans contain some 40 per cent moisture and it is necessary to reduce this below seven per cent before they can be bagged. The normal method is by spreading the wet cocoa on slatted mats raised from the ground. Some farmers dry their cocoa on the ground but this practice is to be discouraged because of the high risk of contamination. The greatest disadvantage of the mat system of drying is that the cocoa is almost certain to get wet in heavy rain and, unless the operator in charge is very efficient, there is a tendency to delay uncovering the beans when the rain has passed over. The drying process is consequently delayed and the risk of mould growth introduced. In the new method of fermentation the trays are of a size which makes them easily handled and, at the end of fermentation, they can be placed on a rail system and rolled in and out of the fermenting and drying shed with considerable ease when necessary.

Figure 13

DESCRIPTION OF TECHNIQUE AT PRESENT IN USE AT W.A.C.R.I.

The pods are broken on wooden benches by hand (*Figure 13*), the contents thrown into open sacks and the husks and placentae into baskets. The husks and placentae are removed and the beans carried to the scales in sacks of approximately 100 lb weight. The cocoa, after weighing, is charged into the fermentation trays, approximately 100 lb in each, and units of twelve trays constructed as described previously. After twenty four hours the stack is covered and fermentation allowed to proceed for another twenty four to forty eight hours. The partitions are then removed, the cocoa spread evenly

and the trays lifted on to the drying rails (*Figure 14*) and rolled into the sun for drying (*Figure 15*). Each evening the trays are rolled back under cover and, when the moisture content of the beans is less than six per cent, the cocoa is bagged, weighed and stored ready for dispatch. During drying, the cocoa is raked over several times each day and the sub-grade cocoa removed.

Figure 14

QUALITY ASSESSMENT

Samples of each experiment were made into chocolate by the method suggested by the Cocoa Scientific Advisory Committee and compared with a standard sample of West African Amelonado by a small panel of tasters at W.A.C.R.I.

SUMMARY AND CONCLUSIONS

A study of the fermentation of West African Amelonado cocoa has shown that the recommended method employing six days fermentation with mixing after two and four days is by no means the most efficient procedure. It was also demonstrated that this variety can be fermented in as short a time as thirty hours at the surface of a fermenting heap. Having established the principle of rapid fermentation this was applied on a large scale and conditions have been described for the proper fermentation of half a ton of wet cocoa in two to three days without mixing. Drying of the fermented cocoa can be carried out in the same vessel used for fermentation thus cutting labour costs. Details are given for the relative handling costs in the fermentation and drying of one ton of dry cocoa using the standard box method of fermentation, heap fermentation and the new technique, described in this paper for the first time.

A new fermentation shed has been designed, and is in process of being erected at the West African Cocoa Research Institute, in which it will be possible to apply this new method of fermentation on a full production scale and it is intended that mechanical aids shall be employed as far as possible to achieve maximum efficiency. On plantations this new system of fermentation should prove more economical than the traditional methods as shown in the results of the costing analyses.

Figure 15

The product of this new method of fermentation is superior in external appearance, uniformity and size of bean to the cocoa produced by the older methods and the quality is well within the range of acceptability for West African Amelonado.

ACKNOWLEDGEMENTS

The authors thank the Director, West African Cocoa Research Institute, for permission to publish. The construction of the new fermentation shed at W.A.C.R.I. is being carried out under the supervision of Mr A. Maddison, station engineer, who has advised on the selection of suitable building materials.

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The Composition and Digestibility of Some Conserved Fodder Crops for Dry Season Feeding in Ghana

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PART IA. RICE STRAW

In Part I of this study, the importance of conserved fodder for dry season feeding in Ghana was emphasized. Since then, regular weighings of store cattle at the Nungua Agricultural Research Station of the University College of Ghana have been carried out as part of grassland management and ecology studies.

This work has revealed that even in an exceptionally mild dry season such as was experienced this year and with an adequate water supply, very substantial losses in body weight occur. In a herd of 30 young animals ranging from 2 to 4 cwt an average loss of 22 lb was observed, due to shortage of grazing (Rose Innes, 1958). From these data it is clear that in a prolonged dry season these losses must assume very serious proportions and the importance of conserved fodders for dry season feeding has not been over-emphasized.

Rice straw has been a late addition to the fodders examined in this study. It was noted in Part I that both hays examined were more readily digested than would have been expected from their appearance and crude chemical composition, since in both cases the crude fibre content was far higher than usual for good hay. It was suggested that the West African cattle used in these trials were extremely efficient in dealing with fibrous material or alternatively carbohydrate may be fixed in more readily digested forms of crude fibre than those which normally occur in this arbitrary fraction.

A study of the literature showed that rice straw has a remarkably constant composition and digestibility throughout a range of authors and localities (*Table 1*). A digestion trial with rice straw was therefore carried out on the assumption that if a significantly greater power of digestion existed in these West African cattle, it should be readily apparent from a simple comparison of the digestion coefficients.

Apart from this aspect, rice straw is becoming increasingly available as the area of rice under cultivation expands under the extension schemes of the Department of Agriculture, and it may well have an important part to play as a by-product in northern areas where the growth of crops for feeding to cattle would be in direct competition with the growth of food crops for consumption by a human population which is already near starvation levels.

EXPERIMENTAL PROCEDURE

The experimental procedure described in Part I was followed throughout except that the same bullocks were not available. Three similar animals, which had taken part in previous digestion trials, were used.

DESCRIPTION OF THE RICE STRAW USED

The rice straw had been threshed and baled in the paddy field where it was grown; a heavy shower fell on the bales prior to carting and the straw when fed appeared to be of only moderate quality.

As the rice straw was somewhat unpalatable the animals were kept on a sub-appetite ration until they were accustomed to it. A ration estimated to be 75 per cent of maintenance energy requirement was fed throughout the preliminary and collecting periods.

Table 1. Composition of Nungua rice straw compared with data from various sources on a dry matter basis

Country	*Reference*	*Organic matter*	*Crude protein*	*Crude fibre*	*N-free extract including ether extract*	*Ash*
India	(LANDER, 1949)	83·5	2·5	36·5	44·5	16·5
India	(LANDER, 1949)	91·3	3·7	35·9	51·7	8·1
India	(LANDER, 1949)	85·8	3·2	33·6	49·0	14·2
India	(SCHNEIDER, 1947)	83·0	2·8	32·4	47·8	17·0
Various	(MORRISON, 1948)	84·3	4·2	36·2	43·9	15·7
Mean	—	85·6	3·3	34·9	47·4	14·3
Nungua	—	85·6	4·0	35·0	46·6	14·4

RESULTS AND DISCUSSION

The analytical data in *Table 1* show the Nungua rice straw to have a similar composition to Indian samples.

In *Table 2* digestion coefficients obtained in the digestion trials at Nungua are compared with coefficients obtained in India.

Table 2. Digestion coefficients of Nungua rice straw compared with rice straw from various sources

Country	*Reference*	*Organic matter*	*Crude protein*	*Crude fibre*	*Nitrogen-free extract*	*Calculated starch equiv.*	*Nutritive ratio*
India	*Lyallpur* (LANDER, 1949)	—	*Neg.*	61	42	20	*Infinite*
India	*Bangalore* (LANDER, 1949)	—	*Neg.*	72	53	32	*Infinite*
India	*Bengal* (LANDER, 1949)	—	*Neg.*	62	46	24	*Infinite*
India	(SCHNEIDER, 1947)	57	2	66	44	24	*Infinite*
Various	(MORRISON, 1948)	—	16	62	48	24	40
Mean		—	—	65	47	25	—
Nungua		61	25	75	54*	35	35

* Includes ether extract.

Digestion coefficients for crude protein, although low, are considerably higher than in the case of trials elsewhere. In the Indian trials reported by Lander (1949), for instance, negative coefficients were obtained.

Digestion coefficients for crude fibre are 15 per cent higher than the mean of the Indian coefficients although the highest Indian coefficient approaches the Nungua results. This confirms that the West African cattle used are extremely efficient in dealing with crude fibre.

Digestion coefficients for nitrogen-free extract are about 7 per cent higher than the mean of the Indian coefficients. It should be noted here that in this study ether extract was not measured separately.

It is clear from these results that the animals used in this trial were better able to digest the rice straw than the cattle used in Indian trials. It may be argued that it is not a valid comparison since external factors such as plane of nutrition may have affected results at different stations, but unless an author specifies abnormal conditions it is assumed that results are not spurious due to abnormal levels of intake.

From the results of digestion trials with natural grassland hay (Lansbury, 1958) and rice straw, calculated starch equivalents have been obtained. Those for rice straw are shown in *Table 2*. These calculated starch equivalents are remarkably high considering the nature of the fodders used. This is attributable to the high digestion coefficients obtained. It would be unwise to assume that these calculated values are accurate because Kellner's correction factor (0·58 g starch per 1 per cent crude fibre) may be insufficient in the case of these fibrous feeds. It has been reported, for instance, that when similar natural grassland hay was fed as a supplement to grazing cattle at the Shika Stock Farm in Nigeria, it actually depressed the rate of liveweight gain. This could only be explained by the use of an excessive amount of energy in the actual process of digestion (Brown, 1938).

Until carefully controlled feeding trials have been carried out to check starch equivalent data calculated from digestion trials, they must be treated with some reserve.

CONCLUSION

The rice straw examined had a high energy value in terms of digestible nutrients. While such rice straw, like the natural grassland hay examined in the first article of this series (Lansbury, 1958), may provide adequate energy, it is very low in digestible protein and would require supplementation for maintenance and production purposes. The West African cattle used were extremely efficient in dealing with crude fibre.

ACKNOWLEDGEMENTS

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Protection of Bagged Maize with Lindane and DDT

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A storage experiment was carried out at the Maize Control storage depot in Nairobi, to compare insecticidal treatments of large stacks of bagged maize. The store used was a converted Mainhill hangar with a storage capacity of about 15 000, 200 lb bags. A dust containing Lindane (active principle: gamma isomer of benzene hexachloride—BHC) to be applied externally to each layer of bags has been recommended in Kenya for many years for the treatment of stacks. In Rhodesia DDT in a water spray has been recommended. The experiment was to compare these two treatments, and included in the experiment was a testing of the value of dusting the floor and dunnage with DDT in local diatomite.

Four stacks were built; each was 20 layers high and contained 3 080, 200 lb bags. The maize was of reasonably common origin, but such a large amount was required that we could not guarantee perfect uniformity. As will be mentioned there was a suspected variation between stacks in initial weevil damage. Two of the stacks had every layer evenly dusted with a 0·5 per cent dust of Lindane in diatomite at the rate of 3 oz per bag surface. The other two stacks had all layers carefully sprayed with one pound of 50 per cent wettable DDT in 1 gallon of water at a rate of 3 gallons per 1 000 ft^2. The floor and dunnage under one of each pair was heavily dusted with 10 per cent DDT in diatomite and the other two stood on untreated dunnage on a clean floor (*Figure 1*). The stacks were fumigated under gas-proof sheets in April 1956. A dose of 2·5 lb of methyl bromide per thousand cubic feet for 48 hours was used so that there could be no question concerning a possible survival. When the above described insecticidal applications are expressed as parts per million (p.p.m.) of maize, the dosage of BHC is equivalent to 4·7 p.p.m., compared to a DDT dosage of 44·0 p.p.m. Unfortunately there were no untreated, control stacks.

The store was closed and remained closed for the duration of the experiment; no grain movements occurred, and the routine sprayings and sweepings were not done. There was very heavily infested grain in neighbouring stores, yet in the experimental stacks the insect population remained light, with the exception of a medium infestation (G/M)* by the moth *Ephestia cautella* Walker.

After thirteen months (in April–May 1957) the stacks were broken down and sampled.

* Infestations noted after a general inspection as defined by the Colonial Liaison Officer of the Pest Infestation Laboratory, Slough, in his 'Definitions for Reporting the Degrees of Infestation in Stored Products in Colonial Territories'.

SAMPLING TECHNIQUE

In each stack ten layers were sampled (odd numbered layers). Nine sampling points were located on each layer. The sampling points from any one layer were placed so as to give a representative sample, yet excluded the two sides of each stack which faced another stack. The top layer was not sampled. By this plan inter-stack influences were assumed to be reduced (*Figure 1*).

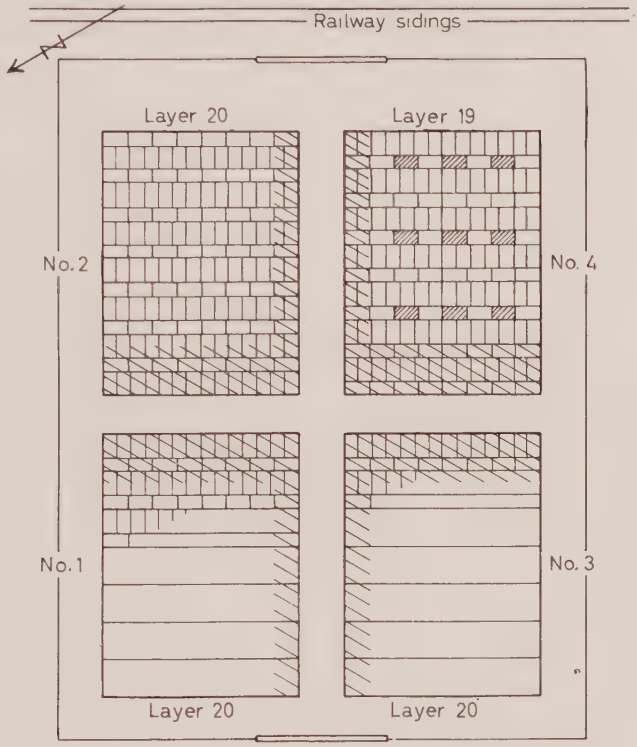

Figure 1. The arrangement and treatment of the experimental stacks. Stacks No. 2 and No. 3 were sprayed with DDT. Stacks No. 1 and No. 4 were dusted with Lindane. Stacks No. 3 and No. 4 had their dunnage dusted with DDT. Layer 19 of stack No. 4 is shown to illustrate the location of the sampled bags. No sampling points were located within the shaded areas at the inner sides of the stacks

A long sampling spear able to take a sample through the length of a bag was used, and only the centre section (one third) was kept from each of the three spearfuls taken from a bag at a sampling point. The total weight of the sample from any one point was about 350 g. The 360 samples were screened and insect numbers were recorded (alive or dead, and species). Using the Doran Mini Potentiometer temperatures were immediately taken in all sampled bags as they were exposed. The ninety samples taken from stack No. 3 also had moisture contents determined with the Marconi Meter (G.A. Scale minus 1·0 per cent).

RESULTS

The sampling disclosed an insect population which was light to medium (S/L to S/M) in all four stacks, and which was largely confined to the upper layers. The only insects found in appreciable numbers were *Tribolium castaneum* Herbst and *Oryzaephilus surinamensis* Linnaeus (*Table 1*). Only two live *Calandra oryzae* Linnaeus were found. Before fumigation with methyl bromide *C. oryzae* is usually the predominant pest in Kenya maize but it rarely becomes re-established in the stores after a fumigation. The absence of *Calandra* may be attributed to the routine practice of a light dusting (about 1 oz per bag) with 0·5 per cent Lindane, but since all other pests become re-established, we suspect an unknown factor. It is to be noted that the practical rate of application of dust has been below that recommended. The only other pest was moth; *Ephestia cautella* cocoons and webbing were found on the bags even in the centre of all stacks, but no moth counts were made.

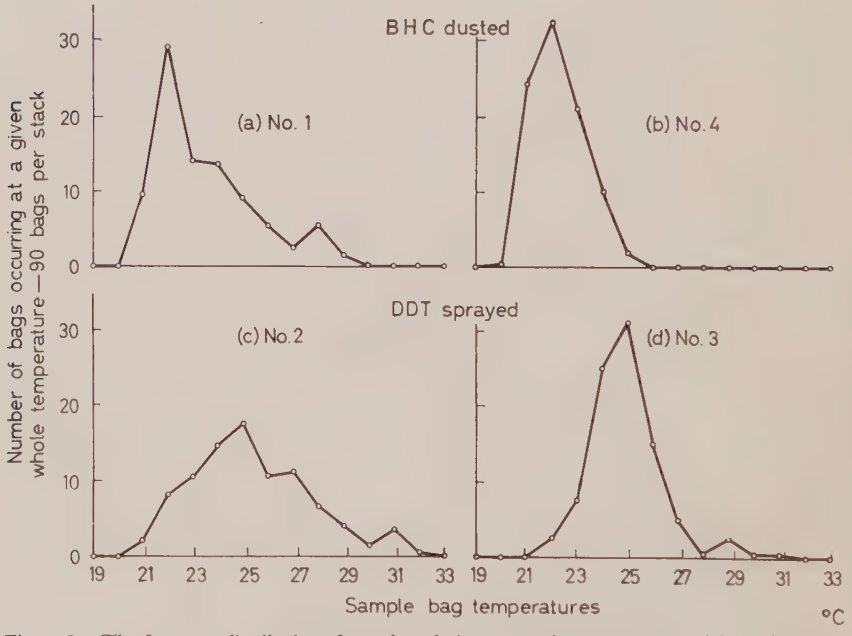

Figure 2. The frequency distribution of samples relative to sample temperatures: (a) *stack No. 1;* (b) *stack No. 4;* (c) *stack No. 2;* (d) *stack No. 3*

Heating of the maize was also restricted to the upper layers. Only the averages and modal values of the ninety temperature readings per stack are shown in *Table 1*, but *Figure 2* (a) to (d) shows for each stack the number of samples occurring at any given whole temperature.

The relevance of the insect numbers and the stack temperatures is illustrated in *Figure 3*. The total number of *Tribolium* and *Oryzaephilus* found in all the samples of a stack are plotted against the average temperature of that stack. As the number of *Tribolium* per stack increases the average temperature of the stack increases. There is no such relationship between

the numbers of *Oryzaephilus* and the average temperatures of the stacks. As can be seen from *Table 1* or *Figure 3* samples from the relatively cool stack No. 1 contained 343 living *Oryzaephilus*, whereas the warmer stacks, No. 2 and No. 3, contained nil and 81.

We could not relate insect and temperature distribution to external factors such as the store orientation, or inter-stack influences. Dead insect numbers are quoted in *Table 1*, but were not considered when conclusions were formed. Percentage mortality data did not show a relation to sample temperature, nor to stack treatment. Other experiments we have done (not yet published) indicate that mortality data can be very misleading, i.e. *Calandra oryzae* apparently consumes a large percentage of its dead. In a study of population trends of *Calandra* in untreated bagged maize, only about ten per cent of the dead *Calandra* could finally be found, and living *Calandra* was most suspect. That the apparently indestructible bodies are not consumed by *Tribolium* is suggested by the results of this stack experiment, for the final counts of dead *Calandra* were in general agreement with the initial counts made thirteen months earlier.

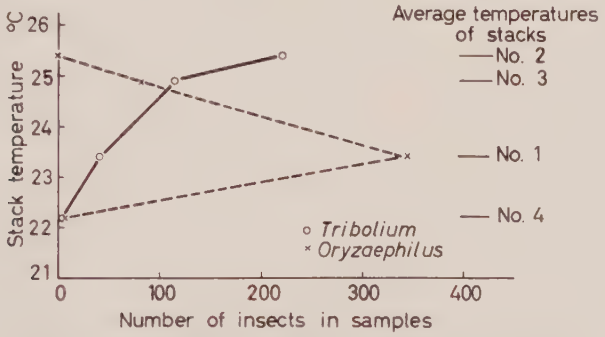

Figure 3. The relevance of the average temperatures of the stacks to the total numbers of living Tribolium *and* Oryzaephilus *found*

That Lindane dusting gave better protection from *Tribolium* is apparent from *Table 1*, but no such clear-cut result is apparent for *Oryzaephilus*.

If the numbers of *Tribolium* found in all samples from a given temperature are summed, and that sum divided by the number of samples taken at that temperature, an average will be obtained: the average number of *Tribolium* occurring in a 350 g sample at that temperature. When such averages are calculated and plotted for a wide range of temperatures, the resultant curve will indicate the temperature preference of *Tribolium*. This curve was calculated for stacks No. 2 and No. 3 (the only stacks where large numbers of *Tribolium* were found), and since the curves were very similar they were averaged to give the curve of *Figure 4* (a). The preference distribution of *Oryzaephilus* was similarly calculated from the data of stack No. 1 [*Figure 4* (b)]. These graphs indicate that *Oryzaephilus* is distributed with a fairly strict dependence upon its temperature preference, which appears to be about 26°C. In laboratory experiments carried out in England (Graham, unpublished) it was found that the peak of *Tribolium* preference in this

temperature region was close to 28° C. The present work cannot be considered precise, for at the higher and lower temperatures few samples occurred, but the indication was that the preferred temperature for *Tribolium* was above 28° C.

The results shown in *Figure 3* suggest that *Tribolium* is responsible for the increase of grain temperature, and *Figure 4* shows that *Oryzaephilus* adhere to a temperature preference of 26° C in establishing their pattern of distribution. Since the temperature of a non-heating stack is less than 23° C, *Oryzaephilus* must be dependent upon the presence of *Tribolium* for the creation of *a preferred environment*. This relationship of the two species must be considered when the results are interpreted. It should be noted that the data shown in *Figures 3* and *4* give no indication of optimum temperatures.

Moisture content determinations in stack No. 3 showed only slight variation from sample point to sample point. The average of the ninety samples was 11·25 per cent. As would be expected the most peripheral sampling locations were of a slightly higher average moisture content.

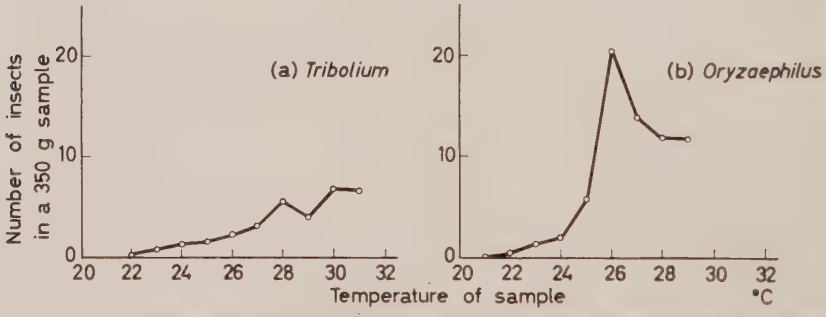

Figure 4. The temperature preference distribution of (a)—Tribolium (*found in stacks No. 2 and No. 3*), *and* (b)—Oryzaephilus (*found in stack No. 1*)

In addition to the sampling and results already outlined, extensive samples were taken with a hand spear, during the early months of storage, from the outside bags of the bottom eight layers. Counts (not included) of dead *Calandra oryzae* and of damaged grain were of a restricted value, yet suggested that initially the four stacks varied in *Calandra* damage in the approximate ratio of 4 : 2 : 1 : 1 (*Table 1*). These results were supported by the counts of dead *Calandra* from the final samples (*Calandra* which had been dead for thirteen months).

A detailed analysis of variance employing all 360 samples was carried out for the numbers of live *Tribolium*. It was shown that the bag treatment with 0·5 per cent Lindane gave significantly better protection from *Tribolium* than the treatment with DDT spray. The floor dusting with 10 per cent DDT made no significant difference in degree of infestation in any of the lower layers. In layer 9 and in most higher layers the floor dusting gave significant protection. It is therefore highly questionable whether this statistical significance is actually a measure of the effect of floor treatment. Possibly an unmeasured variable, or group of variables, coincided with the floor treatment. This variable could be the rate of breakdown of the bag

treatments as influenced by the stack temperatures, or the suspected variation in the degree of *Calandra*-inflicted damage prior to the fumigation.

There was no measure of final insecticidal contamination, but experiments carried out at a later date showed that when 3 oz of Lindane in diatomite is applied to a bag the amount of Lindane that penetrates into the maize is about 0·7 p.p.m. We have since changed our recommendation to 1·5 oz of 1·0 per cent Lindane dust. The penetration at this level of dusting was found to be about 0·8 p.p.m.

Table 1. Summary of sampling results

Stack No.	*Layer treatment*	*Floor treatment*	*Temperature*		Tribolium		Oryzaephilus		*Relative initial* Calandra *damage*
			Av.	*Mode*	*Alive*	*Dead*	*Alive*	*Dead*	
2	*DDT spray*	*Not dusted*	25·4	25·0	221	139	0	0	1
3	*DDT spray*	*Dusted DDT*	24·9	25·0	115	43	81	15	4
1	*Lindane dust*	*Not dusted*	23·4	22·0	40	17	343	88	2
4	*Lindane dust*	*Dusted DDT*	22·2	22·0	4	2	6	2	1

CONCLUSION

Dusting bags of maize with 0·5 per cent Lindane at a rate of three ounces per bag gave a significantly more effective protection from *Tribolium*, than did spraying the layers with 50 per cent wettable DDT (one pound per gallon, at a rate of 3 gallons per 1000 ft²). Both treatments gave ' good ' protection for one year, and the results indicate that the insect populations were just becoming established (treatments breaking down) when the sampling was carried out. In a practical assessment one must consider among other things the relative costs of BHC and DDT and the fact that to get comparable results about 10 times more pure DDT than Lindane was used.

Keeping in mind the possible dependence of *Oryzaephilus* upon *Tribolium* for the creation of a favourable environment, it appears that DDT served better than BHC to control *Oryzaephilus* (no statistical analysis has been attempted). In neither stack treated with DDT spray were there many *Oryzaephilus*; stack No. 3 contained 81 living, and stack No. 2 contained none. Stack No. 3 was possibly more favoured, for the initial damage by *Calandra* in this stack was about four times as great (see *Table 1*). The supposedly less toxic Lindane-treated stacks (No. 1 and No. 4) contained 343 and 6 living *Oryzaephilus*. Stack No. 1 had about 15 per cent of its sample bags at 26° C and above; an appreciable volume of the stack was attractive to *Oryzaephilus*. Stack No. 4, with fewer *Tribolium* present, had none of its bags warmer than 25° C; though not insecticidally immune we assume that the stack was wholly unattractive, and in consequence only 6 *Oryzaephilus* were present.

The Lindane treatment can be considered to have indirectly given a partial protection from *Oryzaephilus*, for in the absence of *Tribolium*, a stack under the conditions prevailing in this experiment will remain relatively cool and unattractive to *Oryzaephilus*. DDT was apparently more directly effective against *Oryzaephilus* than was Lindane, but the proper use of Lindane dust should make this advantage of DDT superfluous.

The statistical analysis of *Tribolium* numbers did not resolve the question of the value of dusting the floors with 10 per cent DDT. Because most of the insects were at the top of the stack, it is questionable whether the penetration of the stack takes place from the floor and whether floor dusting is actually very relevant.

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All staff and equipment costs relative to this experiment were met by the Maize and Produce Control, Kenya. The experiment was planned and initiated by Mrs J. Wells, who left Kenya before the experiment could be completed, and all work was guided by Dr R. H. Le Pelley.

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Bamboo Borers and the Moon

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Of the many superstitions connected with the moon, one of the most widespread is that there is a correlation between the phase of the moon during which timber is felled and its liability to attack by borer beetles. This is believed to be particularly important with regard to the damage done to bamboos by Bostrychid beetles, mainly *Dinoderus* spp. In India, Africa and the West Indies, and probably also in other countries, it is held that bamboos felled shortly after the full moon will suffer less damage than those cut during the first two quarters. In India, according to Beeson and Bhatia (1936), it is believed that during the wane of the moon ' the sap flows down ', leaving the wood dry and more likely to season quickly, whereas the waxing moon is supposed to ' draw the sap up '. It is also thought that injurious insects are more abundant during the period of waxing and full moon. This latter belief is surprising, for it is a matter of common observation that fewer insects are attracted to light on moonlight nights than on dark ones (Williams, 1940) and for that reason nocturnal insects are certainly less conspicuous when the moon is waxing or full, even though there is no proof that the lunar cycle actually affects their abundance or activity (Williams *et al.*, 1956). However, bamboo borers never attack the growing culm, though attack may begin a day or two after the culm has been felled, and the principal cause of the supposed influence of the moon is believed, in Trinidad as elsewhere, to be some action exercised on the living culm shortly before it is felled.

Beeson and Bhatia (loc. cit.) made a number of experiments on bamboos (*Dendrocalamus strictus*) felled at different phases of the moon; they found, rather surprisingly, that there was a cycle of moisture percentage increasing from full to new moon, and decreasing from new to full moon. If there had been any truth in the local belief this should have resulted in increased liability to borer attack in bamboos felled during the waning moon—the opposite of what is commonly held. Actually they found no correlation between the moisture content of a freshly felled culm and its liability to subsequent attack, nor between the phases of the moon and the content of starch and disaccharides in the bamboo, although there was a definite positive correlation between starch content, which varies seasonally but not according to the lunar phase, and borer attack.

In Puerto Rico Plank (1950) compared the starch concentration and borer attack in bamboos harvested, at different times of the year, during the ' increase of the moon ' (i.e. from new up to but not including full moon) and ' decrease of the moon ' (i.e. from full up to but not including new moon). He found that the average starch concentration, with which, in general, intensity of attack is correlated, was almost identical in the two groups; although there was a slightly greater infestation in the culms cut

during the ' increase of the moon ', this was not statistically significant. He concluded that ' from the data available, it may be assumed that powder-post beetle infestation cannot be avoided by harvesting according to the phase of the moon '.

Nevertheless, the belief in the influence of the moon's phases on bamboo borer infestation is so firmly held in Trinidad that it semed that further experiments would not be amiss.

Three local ' experts ' were consulted; all agreed that the best time to fell bamboo was during the waning moon, one giving the ideal time as 2–5 days, one as 2–7 days, and one as 2–8 days after full moon. Conversely, they agreed that the worst time to cut was during the first quarter. Moreover, all three stated that borers would do much less damage to bamboo cut when it was ' ripe '. A ' ripe ' culm is one which is nearing the end of its life, probably at an age of 5 to 10 years; ripeness is judged by the colour of the skin of the culm (which is paler green than in an unripe culm), by the ' ring ' when tapped with the back of a cutlass and by the presence of dead twigs on the upper branches.

Table 1. Number of borer holes 63 days and (in parentheses) 97 days after felling

	Per 100 in² of surface		*Per 10 in² of cut ends*	
Cut during	*Waxing moon*	*Waning moon*	*Waxing moon*	*Waning moon*
Mean of 18 ' ripe ' sections	28 (140)	35 (162)	47	55
Mean of 18 ' unripe ' sections	5 (21)	4 (15)	9	8
Mean of 36 ' ripe ' and ' unripe '	17 (81)	19 (88)	28	32
Mean of 36 sections cut during both moon periods	*' Ripe '*	*' Unripe '*	*' Ripe '*	*' Unripe '*
	31 (151)	5 (18)	51	8

Five days after the new moon occurring on 23 September, 23 October, and 21 December; and after the full moon on 8 October, 7 November, and 7 December 1957, two ' ripe ' and two ' unripe ' culms of *Bambusa vulgaris* Schrad. were felled. The ' ripeness ' and ' unripeness ' was assessed by one of the ' experts ' previously consulted, who was confident that the ' ripe ' culms would be less severely attacked. From each culm a section of an internode eight inches in length was taken from near the bottom, near the middle, and towards the top where the diameter was not less than about two inches. These were kept in a greenhouse together with a number of pieces of bamboo heavily infested with *Dinoderus minutus* F., to ensure a large initial population. The test sections were examined for borer holes 63 days after felling; because the sections were not all of the same diameter and there was considerable variation in the thickness of the walls, the data in *Table 1* are the numbers of borer holes per 100 square inches of the surface and per 10 square inches of the cut ends. A further count was made 97 days after felling; by then the number of holes in the cut ends had increased

so greatly that, in several of the ' ripe ' sections, numerous holes coalesced and it was impossible to count them with any degree of accuracy. Details for the 97-day counts are therefore given only for holes on the surfaces of the sections.

Although there is apparently a slightly greater tendency for bamboo felled during the waning moon to be attacked (the reverse of the local belief) the difference is not significant. On the other hand, ' ripe ' culms are attacked much more heavily than ' unripe ' ones, and the difference is highly significant ($P = < 0{\cdot}001$).

Although the local belief that ' ripe ' bamboo is less liable to attack by *Dinoderus* is clearly erroneous, there is nevertheless some advantage in cutting bamboo when ' ripe ', for it is less likely to split. About two months after felling, 17 of the 36 ' unripe ' sections had split, but only 4 (three of which were from the same culm) of the 36 ' ripe ' ones.

CONCLUSIONS

Bamboo cut with moon on wane
Will ensure financial gain;
But beetles bore it very soon
If cut upon the waxing moon;
Moreover it's a well-known fact
That ripe bamboo is less attacked.

So say the chaps who ought to know,
Alas! It really is not so.
For Science reared its ugly head
And killed these superstitions dead;
The lunar myth is utter tripe
And borers *like* their bamboo ripe.

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Ensete *Cultivation in the Southern Highlands of Ethiopia; a Review*

In a recent article, Smeds (1955) has described the *Ensete* agriculture of the Sidamo area of southern Ethiopia and his observations are thought to be of such great general interest as to be worth bringing to the notice of tropical agriculturists in the form of the review presented here. Reviewer's notes are enclosed in square brackets. The reviewer expresses his thanks to Dr H. Smeds, Mr E. Milne-Redhead and Professor C. C. Webster for helpful comments.

LOCALITY AND ENVIRONMENT

The Sidamo area of southern Ethiopia is one of the most densely populated parts of the country, having roughly 150 to 175 people per square kilometre (equivalent to 390 to 450 per square mile). The people are polygamous pagans who are physically similar to but culturally quite different from the Amharic folk who live to the north. Topographically, the country is mountainous and the *Ensete* agriculture lies at high altitude (1 600 to 2 800 m, say 5 300 to 9 200 ft) (see *Figure 1*). [The zone of cultivation extends above the normal altitudinal limit of the species in East Africa where the upper edge of its distribution seems to lie between 7 500 and 8 000 ft.] The annual rainfall in Sidamo is about 80 inches (2 000 mm), fairly well distributed throughout the year. Annual mean temperatures range between 52 and 70° F (11 and 21° C), depending upon altitude; frosts occur at the higher levels.

THE ENSETE AGRICULTURE

General features

The agriculture of the area is permanent in the sense that a village works a given patch of land indefinitely; it consists essentially of a combination of *Ensete* (grown as the staple food plant) with pasture carrying stock. Pasture-*Ensete* rotation is not practised in the area studied by Smeds though it is known elsewhere in Sidamo. Bamboo is an important economic plant, and cabbage and barley are significant minor crops. In one village surveyed 16 per cent of the land was cultivated, 6 per cent was in bamboo groves and hayfields and 78 per cent was in pasture; this is probably fairly typical. Animals are stalled at night and their manure is accumulated in heaps for later distribution to the cultivations. Cultivation is by wooden hoe and digging stick, the plough being unknown although generally used in northern Ethiopia. The *Ensete* fields and bamboo clumps are protected against stock by plaited bamboo fencing and the whole gives the impression of an intensive and extremely well managed agriculture.

[There would appear to be some local variation in the structure of the *Ensete* agriculture within southern Ethiopia for J. Gillett (Milne-Redhead, personal communication) has noted that, in the Agheremariam district, *Ensete* is planted in a *Podocarpus* forest area in association with barley but without bamboo.]

Ensete *cultivation*

[The species in question is called *Ensete edule* Horan. by Smeds but is better referred to by the name *E. ventricosum* (Welw.) Cheesman which is the common widespread species of east and central tropical Africa (Baker and Simmonds, 1953) (see *Figures 2* and *3*). It is known from Kenya and Uganda south to Mozambique and the Transvaal and west to the Congo and the Cameroons; in Ethiopia it is, according to Smeds, very scarce as

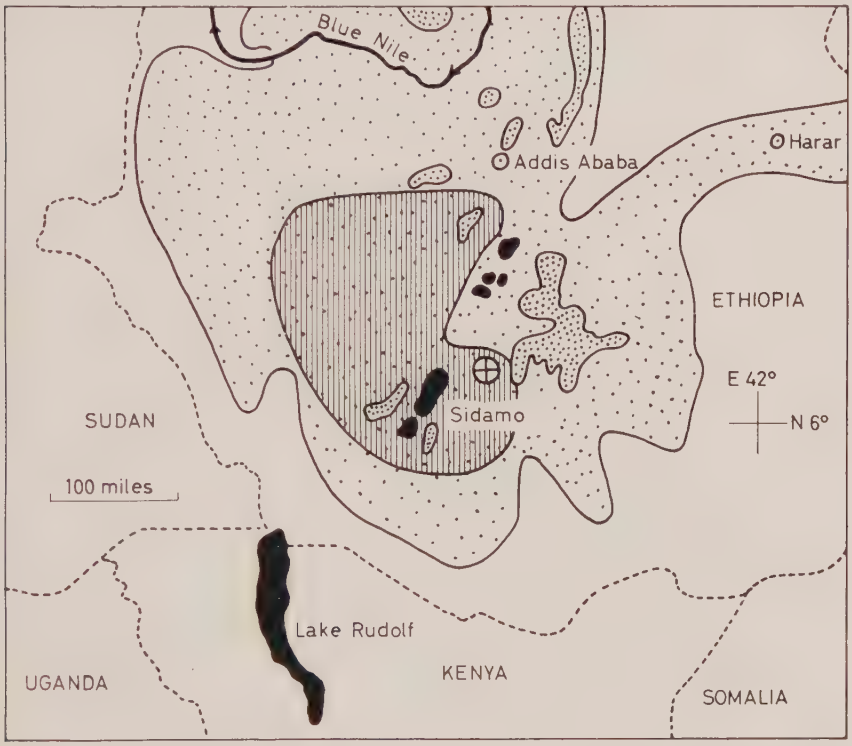

Figure 1. Sketch map of southern Ethiopia to show position of Sidamo. Land over 5 000 feet lightly stippled; land over 10 000 feet heavily stippled; lakes solid black; political boundaries dashed; main area of Ensete *cultivation vertically shaded; district in which the Finnish Expedition worked indicated by cross in circle*

a wild plant and, though certainly subspontaneous in places, perhaps not truly native.] The plant is propagated vegetatively, a six-year old corm being hollowed out and packed with a mixture of soil and dung; the treated corm is then planted and produces numerous suckers which are raised in nurseries for later transfer to the field. [Since *E. ventricosum*, like other members of the genus, is monocarpic, this method of vegetative propagation is of considerable general interest; presumably it depends for its success upon the fact that the treatment is applied before flowering has depleted the starch reserves of the corm. Limited experiments with ordinary bananas (Wright, 1950 and the reviewer, unpublished) gave no indication that the treatment stimulated suckering in bananas that sucker naturally.] Elsewhere in Ethiopia, seed propagation is known and sometimes used but,

in the high altitudes of Sidamo, growth is so slow that the people hardly know that the plant is capable of flowering.

The normal maximum life of a plant is six or seven years and reaping starts when the plants are about three years old. Planting is very dense, so dense that vision and movement are both severely restricted in the field; an estimated average space per plant is 10 m^2, equivalent to a 10 ft $\times$ 10 ft square planting (420 plants per acre). There are about 60 plants per head

Figure 2. A clump of Ensete ventricosum *plants in fruit at the Scott Agricultural Laboratory near Nairobi, Kenya (photograph by the late Professor R. E. D. Baker, 1948). The seed from which the plants in this and the suceeding figure were raised came from Ethiopia*

of the population which, allowing an average five-year cutting cycle, would mean that 12 plants per head per year is the average consumption—this seems a likely sort of number, certainly more likely than the three plants per head per year estimated by earlier authors. On the basis of the planting density given above, an area of 0·15 acre supports one human being; add to this five times the same area to allow for the pasture and bamboo and we have a total of 0·9 acre of land per head of population. [This is intensive agriculture by any standards; for Africa it is exceptionally intensive, being

surpassed probably by only a few areas such as Ukara Island in Lake Victoria where the people subsist on about 0·5 acre per head (ROUNCE and THORNTON, 1956).]

There are said to be some forty distinct kinds of *Ensete* in Ethiopia, implying seed propagation in the past if not today. The principal vernacular names are: *inset* in Sidamo, *hutta* in the Kullo language of Kaffa, *uarki* in Galla, *kojo* in Amharic, and *guna-guna* in Tigraean. [The generic name,

Figure 3. A pre-flowering plant of Ensete ventricosum. *Place and source as in Figure 2*

Ensete, derives by way of the original botanical name, *Musa ensete* Gmel., from the same root as *inset*, recorded by Bruce on his travels in Ethiopia.]

Uses

Most of the plants are used to provide food and fibre. Men cut the pseudostems at ground level and, having removed the leaves, carry them to a suitable preparation point in the field. Women split the sheaths and decorticate the resultant strips with a bamboo knife holding the strips against an inclined plank with a foot as they do so. The pulp so removed is accumulated in circular pits which are roughly 3 ft × 3 ft in size and lined with *Ensete* leaves; when the pit is full it is covered with more *Ensete*

leaves and, finally, with stones. The contents are left to ferment for two or three months, sometimes for a year but not (contrary to earlier accounts) for more than a year. The fibrous strips of sheath from which the pulp has been removed are collected, dried and used to make string or rope. [Cordage made from this fibre is said to appear sometimes in northern Kenya as an article of commerce carried in by wandering Ethiopians. According to J. Gillett (Milne-Redhead, personal communication) the fibre is of considerable commercial importance in Ethiopia, being processed into rope, twine and gunny-bags by a factory in Addis Ababa that is devoted wholly to the crop; the factory in 1952–3 produced some 40 per cent of the country's requirements of gunny-bags.]

The fermented pulp, after extraction from the pit, is pressed to remove the acid fermentation liquid and the starchy paste that remains is cooked for human consumption; it is either rolled out and baked to make a thin bread or is boiled in oil (from *Guizotia abyssinica*) to yield a porridge. The bread is generally eaten with porridge made of boiled cabbage leaves. The leaves of the *Ensete* plant are used for many household purposes, for example: lining and covering the fermentation pits as described above; for wrapping, as plates and for thatching the bamboo-framed huts mentioned below.

In parts of Ethiopia (but not in Sidamo) the heart of the pseudostem of the same plant (*ammicho*), stripped of the fibrous outer sheaths, is boiled and eaten as a vegetable [just as the inner sheaths of species of *Musa* are eaten in parts of northeastern India.] The early traveller in Ethiopia, Bruce, writing in 1770, besides describing the *Ensete* as ' one of the most beautiful productions of nature ' also noted that the boiled pseudostem ' has the taste of the best new wheat bread not perfectly baked '. He made no mention of the preparation of a starchy fermented paste which was evidently then, as it is now, virtually confined to the southern part of the country. [Smeds (personal communication), however, disagrees with this oft-quoted opinion of Bruce in thinking that *ammicho* resembles in taste a ' well-boiled Irish potato '.]

Associated crops and stock

A perennial cabbage (*Brassica integrifolia* var. *carinata*) is the only other significant food plant of the people. It is generally interplanted in the *Ensete* fields and must present an extraordinary sight to European eyes; the plants are up to 6 ft tall and they crop continuously for three to four years, leaves being stripped off as required. The leaves are eaten as a boiled porridge with *Ensete* bread, as mentioned above. Barley (*Hordeum intermedium*) is of minor importance as a crop, being grown for the grain which is acceptable to the Amharic landowners as payment for rent of land; it is generally made into *talla* (beer). A bamboo (*Arundinaria alpina*) is native to the region and is of very great importance in the culture; though wild, it is, in effect, a cultivated plant to the Sidamo people. Clumps are scattered throughout the area rather than gathered into definite plantings. In the *Ensete* fields they are automatically protected against stock by the bamboo fence which surrounds the land; in pasture, clumps are individually fenced against stock. They are regularly pruned in order to produce the desired form of pole. The wood is used for building (the local huts have beautifully woven bamboo

frames); fencing is made of woven bamboo strips; water carrying and storage is done in pots made from the basal internodes of large culms; and spears, digging sticks, etc., are also made from the plant. The animals raised locally are horse, ass, cow, sheep and goat but not the fowl—common as this bird is in northern Ethiopia. The Sidamo people very rarely eat meat but they drink milk and use the hides for clothing; the horses are ridden and horses and donkeys are made to carry loads.

GENERAL

The history of this extraordinary agriculture is far from clear. One plausible view is that it is a relict of the agriculture of early negroid or pygmoid inhabitants whose lands were invaded from the north by Semitic folk who used the plough and planted seeds rather than vegetative material [cf. SAUER, 1952]. Islands of the *Ensete* agriculture survive in northern Ethiopia even now and it looks as though the culture may once have been a widespread and important one in East Africa.

[In favour of this view is the work of LAURENT-TÄCKHOLM (1951) (see also TÄCKHOLM and DRAR, 1954) which showed that the plant was important enough in upper Egypt in Middle Pre-Dynastic times to have signified the idea of the 'south'; a pictogram based upon it later became a hieroglyph meaning the 'south' and it is possible that the plant was the 'byssus' plant which yielded fibre to make the royal linen. Laurent-Täckholm surmises on this basis that *Ensete ventricosum* was once an important food and fibre plant in upper Egypt, perhaps more widespread during a neolithic wet phase than it is now. Against the hypothesis, however, is SMED's observation (personal communication) that the scattered negroid peoples of southern Ethiopia are not *Ensete* planters; furthermore, it is hard to conceive of *Ensete* agriculture existing (at least in its intensive form) without the stock on which it depends for manure.]

Whatever the early history of the agriculture, the present situation is that there are now three economies in Ethiopia—the *Ensete* planting economy, the nomadic cattle herding economy and the Amharic–Tigraean plough-and-seed economy. The last is an invasive culture introduced from Arabia during the first millennium B.C.; it has largely, though not entirely, supplanted the other two economies in northern and central Ethiopia. The process of invasion is not yet ended but it would appear that present gains are made principally at the expense of the herding economy—the *Ensete* agriculture being more or less stable, advancing a little here and regressing there.—N.W.S.

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Book Reviews

THE GRASSLAND AND FODDER RESOURCES OF INDIA

R. O. Whyte. Indian Council of Agricultural Research: New Delhi, 1957. *viii* + 437 *pp.* (illus.) *Rs*16

This book is a result of a special study undertaken by Dr R. O. Whyte of the F.A.O., whose services were lent to the Indian Council of Agricultural Research, of the problems connected with grass and fodder vegetation. It will be of particular interest to general agriculturists, foresters, research workers, administrators and rural planners, in India (particularly Northern and Western areas).

The first chapter outlines the ' Livestock Problem ' of India in general and summarizes views and recommendations from the many surveys and commissions that have been appointed during the last 60 years.

An assessment of the grassland and fodder resources is one of the most complex of exercises for any country, even one for which reliable statistical data are available and an additional complication in this subject is the area and production of ' forest grazing '. Dr Whyte has made an attempt, which should serve as a working basis for many years, by drawing up a balance sheet of fodder supplies and livestock demands. Leaving aside equines, sheep, goats, poultry and pigs, most of which are self-maintained by free range foraging, the requirements of the bovine population, which is the crux of Indian animal and *pari passu* human nutrition problems, are met to the extent of 23 per cent for digestible crude protein and 38 per cent for starch equivalent. It is emphasized that good quality livestock cannot be maintained in good condition on Indian grazing lands alone and that a properly designed pasture and fodder calendar should be aimed at to utilize grazing, fodder, crop residue and other feed sources.

Turning to the study of the vegetation itself, an ecological approach is made. India is not a country of climax grassland, although biotic factors have led to the development of considerable areas of grass within areas of forest administration. Chapter IV, dealing with the grassland types of which eight are tentatively recognized, will have most appeal to the agrostologist. Indian grasses have received considerable individual attention from botanists such as Dr N. L. Bor, but their ecological associations remain relatively unstudied.

A chapter follows on grassland management and fodder production on Government and Military Farms; whilst these cater for but a very small proportion of the total cattle population, they do serve to indicate systems whereby local improvements might be made. The section on Village Grazing Lands presents a dismal picture of uncontrolled over-grazing, and any attempt at improvement necessitates temporary removal of stock; although the social and political situations involved in such a scheme are likely to be delicate, a working plan is proposed which involves rotational concentrations

of stock into ' dry plots ' of one seventh of the area with hand feeding, whilst the remaining six sevenths receives simple regenerative treatment. The basic problems of reseeding as a means of pasture improvement have scarcely been worked on. The state of the rural economy is such that any land fit for the plough must grow directly consumable or cashable crops. The author considers that ' under the existing and probable future conditions in India, it does not appear that reseeding of natural pasture is likely to be undertaken on a large scale '. The three chapters dealing with the subjects of nomadic and forest grazing and their regulation are of application mainly to the northern and western areas.

A review of fertilizer experiments with grass and legumes indicates that nitrogen and phosphorus are the chief deficient minerals. This section includes an interesting catalogue of many different cropping rotations that incorporate a legume. It is considered that the inclusion of a well chosen legume as a dual purpose animal fodder and soil improver, particularly in grain farming areas, is both practical and highly desirable.

The natural grasses have a wealth of varying types and ecotypes, and breeding has been in progress since 1953 at New Delhi for improvements in species adapted to the semi-arid regions of North India. Short term legumes are also under selection. Work at other centres is noted. It is clear that pasture research including a survey of introductions is only in its infancy, whilst that for fodder and legumes is well established with, in the Punjab, considerable demand for seed.

Thus whilst it is fully realized that ' grassland management and fodder production are the keys to correct land use and agricultural improvement they are the most neglected aspects in research and practice '.

The improvement of fodder resources is intimately bound up with farming systems and land tenure and Dr Whyte devotes suitable space to their consideration: ' The chief deterrents to the provision of animal fodder on a year round basis in India may be said to be the monsoon climate and agrarian structure '.

The book concludes with a descriptive and pictorial account of a number of cultivated and introduced grasses and legumes.

There are 260 references and 50 photographs of landscape and vegetation which are well reproduced except for a few blurred close-ups of grass foliage. The text is well spaced in clear print; all botanical names are italicized and no typographical errors were noticed by the reviewer. The soils map of India suffers from microscopic legendry and some of the rainfall diagrams have not been reproduced very clearly but apart from that the Swan Press of Lahore deserves credit for a high standard of publication.—R.H.F.

AGRICULTURE IN NATAL: RECENT DEVELOPMENTS

(NATAL REGIONAL SURVEY VOLUME 13)

By members of Department of Agriculture, University of Natal. Oxford University Press: Cape Town, 1957. $x + 205$ *pp.* (illus.) 45*s*

This volume is the thirteenth in a series prepared by the University of Natal on behalf of the Council for Social and Economic Planning of South Africa. The twelfth of the series dealt with Agriculture from 1860 to 1950

and the one under review is subtitled ' Recent Developments '. Since, however, it is virtually a discussion on facts obtained in the 1950 Agricultural Census such a description may be most misleading to the agronomist.

The first three chapters deal with climate, soils and vegetation in considerable detail; as components of a review of ' Recent developments ', however, their place would more appropriately have been the previous volume, and joint instead of separate authorship might have avoided the repetition of treatment of ' Natural regions ' under ' Climate and vegetation '. It is pleasing to note, however, the ' agro-ecological ' approach in the treatment of climate.

The inclusion of a map showing physical features, towns and communications would have added interest.

In the soil section subdivisions of three basic types—Podsolic, Lateritic and Miscellaneous—are briefly described with notes of extent and agricultural potential; then follows a treatment of soil fertility problems in which the basic one of most humid-tropic soils, namely intense weathering leading to a high degree of acidity, is revealed.

The natural vegetation is divided into nine types and listed botanically, some good photographs are included and a summary suggests that ' veld management is of prime importance and that cultivated pastures may be of value in the future possibly as leys in crop rotation '.

Regarding cane cultivation, current production of just under a million tons of sugar from eight million tons of cane represents a near maximum potential unless more land is released from Crown or Native Reserve areas. The spread of irrigation is limited by the undulating topography and physical shortage in the rivers. South Africa as a whole is comparatively free from serious insect pests but little mention is made of virus or other disease.

The chapter on the Wattle Industry, founded by John Vanderplank in 1864 and based on the two species *Acacia mollissima* (black wattle) and *A. decurrens* (green wattle) is the most informative and well balanced in the book. The industry is well served by its own research organization on problems of silviculture, breeding and processing.

Dealing with field crop production, in which Natal offers the agriculturist a wide range from temperate to fully tropical, the point is made that non-climatic factors, particularly economic, exert considerable influence on choice of crops. The treatment given is based almost entirely on an economic review of the situation and no agronomic information is presented. Although maize is the second most important crop the province imports 3 000 000 bags a year as animal feed. This imbalance is due largely to inability to conserve sufficient of the abundant grass production. Two basic problems limiting crop production are restriction of arable acreage and inefficiency of weed control.

Fruit and vegetables are dealt with shortly; of the former (citrus, bananas, avocado pear and the promising canning pineapple industry) it is revealed that although Natal has many parts suitable for their production and in spite of increasing world demand for these items, acreage is falling; this is attributed to expansion of cane land and a number of ecological problems

of which frost is important. The production of the eight main vegetables, in which Natal is not self-supporting, is discussed in one page.

In view of the serious problem of erosion, particularly in the hilly and overstocked non-European areas, a more detailed report might have been produced. However, a broad outline of the work of the Department is given and a description of the working of the Soil Conservation Act which gives the State wide powers over the 34 currently proclaimed areas. The Act does not apply to Native areas. The Department of Native Affairs deals with this side of the problem in terms of ' betterment areas ' but progress is slow owing to the requirements of vigorous stock culling.

The section on animal production is a somewhat dull catalogue of statistics and breakdowns of livestock numbers obtained during various censuses and comparison with the Union as a whole. No costings or values are attached to any of these details and the data on cows apply to European enterprises only. The dairy industry is introduced by a general consideration of the stages in evolution that such an industry must go through from early settlement days to the present day competitive agro-industrial community. It is surprising to find that ' a limiting factor of unusual force ' is the low milk yield; a daily average of 1·5 gallon being considered high. Poor quality stock and a deficiency of good feed appear to be responsible. The demand for butterfat products whether as fresh milk or processed cheese is high and expanding.

The poultry industry suffers from difficulty of marketing owing to transport problems and seasonal production, neither of which is unique to Natal nor insurmountable.

The book concludes with a short analysis of intensity of production in terms of gross income per 100 morgen, in which the highest is seen to come from medium sized sugar estates; and a review of labour resources. This latter reflecting as it does the unique social organization developed as a result of the break-up of the Zulu tribes, deserves a more prominent place at the beginning of the book. It contains virtually the only reference to the native as distinct from the European. The rates of pay are low; the sugar worker, for example, who is the highest paid, receives about a quarter to one fifth of what his counterpart in ' The West Indies ' might expect. In general there is a shortage of field labour consequent upon a drift to the towns.

The book is well printed on good quality paper and contains sixty photographs and nine diagrams.—R.H.F.

COCOA CONFERENCE 1957

Cocoa, Chocolate and Confectionery Alliance: London, 1958. *xiv* + 326 *pp.* (illus.) 63*s*

In 1957 the tenth international conference on raw cocoa held in London since the war (the ninth to be organized by the Cocoa, Chocolate and Confectionery Alliance) met to discuss technical and scientific matters in the field of cocoa cultivation, and was attended by 268 delegates representing all the main producing and consuming countries and nearly all the organizations with a direct interest in cacao-growing throughout the world. The

conference was primarily an agricultural conference and the report of its proceedings, which has now appeared, is a document of particular interest to the agricultural scientist. It is more than twice as large as the report of the 1955 Cocoa Conference, and of this difference only about 35 pages are accounted for by the innovation of giving full translations of papers that were presented in French, in addition to the original text.

The ' meat ' of the report consists of the contributions to the technical sessions. These covered the commercial background, reviewing problems and prospects with regard to the demand for cocoa, development in new cacao-growing areas, with particular reference to Malaya and Fiji, planting materials and methods, disease and pest control, the chemistry of cocoa fermentation, preparation and quality, and, finally, the cacao tree in its environment. The communications of the first three sessions occupy about 70 pages of the text, whereas those of the sessions on pests and diseases, on cacao preparation in all its phases, and on the tree itself take up some 70 pages each.

As the papers are couched in almost a conversational style the compendium supplies a most readable summary of the current position, and, notwithstanding the permissible caution with which contributors evaluated their future activities, also gives a good idea of the lines along which further progress is to be expected. The amount of solid factual information dispersed throughout the report is impressive, and the compilers have performed a useful service in providing a comprehensive index. Many of the contributions are accompanied by bibliographies listing recent papers relevant to the topic discussed; these are likely to be decidedly useful to the agricultural scientist as it may fairly be assumed that on account of their extreme diversity of location he would otherwise remain unaware of the existence of many of them.

In combining a most stimulating discussion of the outstanding problems of cacao production with the authoritativeness and almost the scope of a textbook, the book, at three guineas, is good value.

Just as the excitement of following a serial terminates in a feeling of frustration when the spell is broken and the reader is urged not to miss the next instalment, so one lays down this report with an inevitable sigh of regret that so many of its ' stories ' do not get as far as the dénouement. In saying ' We . . . would welcome practical advice on the use of fertilizers ' Mr Boys of the Planters' Association of Ceylon doubtless echoed the thoughts of all progressive cacao planters. Yet that practical advice may even now be no farther away than the results of experiments already in progress, and when it is offered it will be accompanied by equally necessary advice on the amount of shading and level of water supply needed to match. Similarly the estate manager anxious to learn what types of cacao to use in his new plantings would doubtless welcome a more definitive statement than can be given at present. He, too, may not have long to wait. One could plead for the next Cocoa Conference to be deferred until at least one of the major lines of investigation has attained its short-term objective, so that the implications of the results could there be presented in terms of estate procedure, and one of the stories thus could be brought to a satisfying end. —R.G.F.

THE PACIFIC LOWLANDS OF COLOMBIA

R. C. West. Louisiana State University Press: Baton Rouge, Louisiana, U.S.A., 1957. *xiv* + 278 *pp.* (illus.) $5.00

The Pacific lowlands of Colombia comprise the area between the western flank of the Andes and the Pacific. This area is about 600 miles long and 50 to 100 miles wide; it stretches in an arc from the frontier with Panama in the north to Esmeraldas in Ecuador in the south. In reality the lowlands contain several land types but are considered by the author as one cultural entity as more than 80 per cent of the inhabitants are of Negro descent making it one of the major Negroid areas in the Americas. The region is sparsely inhabited with a density of about ten persons to the square mile. Buenaventura is the only centre of population of any size, being the second seaport of Colombia; it lies almost exactly in the centre of the arc.

An outstanding feature of the Pacific lowlands is the high rainfall. A large portion receives over 200 inches of rain annually and in some parts an average of over 500 inches has been recorded. The latter are probably the wettest places in the tropics. This large precipitation is distributed throughout the year and in the inland areas most of the rain falls at night. The growth of the population and the development of the natural resources have been hindered by the lack of good agricultural soils, poor transport facilities and disease, and the high rainfall is mainly responsible for these barriers to development.

There is a detailed account of the geography and types of vegetation and of the inhabitants of the area, their occupations and mode of living. A large portion of the book is concerned with the economy. The gold and platinum mined in the Chocó provide much of the wealth. Apart from mining, agriculture is the main occupation although forestry and fishing provide a means of livelihood for a large part of the population. The agriculture consists largely of subsistence farming since good soils are rare. A unique feature of cultivation is the bush-mulch system which is used instead of fire for clearing the land in many parts where a definite dry season does not occur. The main food crops are maize, rice, sugar cane, plantains and bananas. The latter are becoming of increasing importance as an export crop. The rearing of animals is difficult and the region has to rely on the upland areas for most of the meat supplies.

The book is very well illustrated with numerous photographs and maps. However, when reading the book a need is felt for one complete map of the localities and rivers mentioned in the text. About 50 pages are devoted to notes on the various chapters. Much of the material in the notes could have been included in the text and a less bulky work would be appreciated. The author appears to be uncertain of the gender of the Colombian name for the palm *Guilielma gasipaes*.

Several attempts have been made in recent years to colonize parts of the Pacific lowlands but little success has been achieved as compared with other lowland areas of Colombia. The book clearly indicates the difficulties involved but it will be of interest to see how the natural resources will be developed in the future.—B.G.D.B.

CO-OPERATIVES AND LAND USE

M. Digby. *F.A.O. Agricultural Development Paper No. 61.* F.A.O.: Rome, 1957. *viii* + 115 *pp.* 5*s*

It is understandable that the secretariat of the F.A.O. had some trouble with the title of this number in their series of development papers; none could fully describe the field covered and the one chosen is not very informative. The *Paper* actually reviews the whole range of what may be very loosely termed cooperative farming—from the completely communal *kibbutz* in Israel to the irrigation cooperatives in the Western U.S.A. and consolidated holdings in the Punjab. Nor does the *Paper* confine itself strictly to voluntary self-supporting cooperatives; even the Gezira scheme of the Sudan finds a not incongruous place. Indeed it is notable how few such schemes originate from and survive on the voluntary effort of the population. They are often linked with schemes of subsidization of one sort or another.

Although, or perhaps because, the *Paper* is all-embracing, no particular schemes are described in any great detail. It is intended and should serve as an invaluable index for cooperative activity in all aspects of production. It should allow the planner to discover where a particular type of organization of agricultural production that he favours has been tried; exactly how the organization is run and how successfully can only be ascertained by further enquiry.

In some ways it is a pity that the *Paper* is a catalogue rather than a criticism. Miss Digby's great experience and understanding of all kinds of cooperative effort are allowed little scope in such a review. Although never exceeding her commission, the author does from time to time let slip a profundity that indicates what a valuable critique she could write on this subject. For instance: ' those to whom the cooperative farm appeals are either the intellectuals without previous farming experience; the technically-minded, to whom machines and all that goes with them are more important than the bare ownership of land; the more dependent type of share-cropper and labourers with no experience of managing farms of their own; or tribal peoples who have no tradition of individual ownership '.

The F.A.O. or some other organization would render a most valuable service to tropical agriculture by inviting Miss Digby to analyse and criticize some of the recent schemes of land settlement and cooperative farming in the tropics.—A.L.J.

CROP PRODUCTION: PRINCIPLES AND PRACTICES

H. D. Hughes and E. R. Henson. Revised edition. Macmillan: New York, 1957. *xii* + 620 *pp.* (illus.) 48*s* 6*d*

This book is designed to give a general background of methods of crop production for North America. It has served as an agricultural textbook for college students in that area for many years. This edition has been entirely rewritten, improved and brought up to date.

The book itself might be divided into two parts. In its preliminary chapters the first part places the crop production of North America in

perspective with that of the world, and subsequent chapters go on to deal with the principles of crop production, the effect of climate and soils, rotations and many other aspects of crop improvement. The second part deals with the cultivation of specific crops, the most important being corn, sorghum, barley, oats, soy beans, cotton and tobacco. Grass and legumes and their use are examined in detail. A few final chapters discuss storage of seed, pests, diseases and weeds. Herein lies possibly the book's main fault. It tries to achieve a little too much in one volume.

The book is well illustrated, annotated and very readable. Its value, however, to the agriculturist of the tropics, other than being a reference to the methods of cultivation of the agricultural crops in the U.S.A., is decidedly limited.—J.S.C.

QUANTITATIVE PLANT ECOLOGY

P. Greig-Smith. Butterworths Scientific Publications: London; Academic Press: New York, 1957. *ix* + 198 *pp.* (illus.) 30*s*, $6.00

' At the present stage of development of plant ecology, when the great value of a quantitative approach is becoming apparent, there is a tendency either to apply quantitative methods too enthusiastically, or to apply them to problems to which they are not, or not yet, appropriate '. So writes the author in the opening sentence of his last chapter. He has succeeded in making a balanced assessment of many of the problems which face the ecologist, be he botanist or agriculturist, turning to quantitative methods of studying vegetation.

The first two chapters deal with basic principles—the different methods of describing vegetation in quantitative terms, sampling and comparison. These two chapters should be studied carefully by all ecologists, especially those planning a quantitative study of vegetation. As a result, much time and effort will be saved and there will be an increased probability of producing useful results.

Chapter 3, on ' Pattern ', is no less important and deals with the distribution patterns of individual species. In particular, the reader will find guidance as to which of the rather numerous tests for randomness to apply under various circumstances and how to apply it. However, as the author points out, ' detection and analysis of non-randomness is a starting point for further investigation of the factors responsible and not an end in itself '. Chapter 4, on ' Association between species ', deals with the relationships between the patterns of different species and chapter 5 is on ' Correlation of vegetation with habitat factors '. Both these chapters contain valuable lessons in the handling of quantitative data in the most effective manner and show clearly the conclusions which may be drawn from particular analyses.

The frontiers of ecology are reached in chapter 6, on ' Plant communities '. What is a plant community? Can they be classified? It is clear that ecologists are still far from knowing the answers to these questions. Greig-Smith gives an up-to-date review of this rather confused field.

The final chapter sums up ' The quantitative approach to plant ecology ', and points to recent work which has been tackled on the right lines.

It is assumed that the reader is already familiar with simple statistical

analyses such as calculating a standard deviation. Less familiar analyses are dealt with step by step, but in some cases it is doubtful whether the non-mathematician will be able to follow these steps (e.g. p 134). It is emphasized, however, that such calculations form a very small part of the book and, even if not understood, should not affect the comprehension of the text.

One appendix gives a brief discussion of the handling of meteorological data and ' area and spread of species '. There is also an appendix of six tables relevant to the text. The bibliography contains 190 important references of current practical value.

The progress of agriculture and forestry in tropical regions often depends upon answers to ecological questions. Some of the answers will be found by using the quantitative approach to plant ecology so ably demonstrated and assessed by GREIG-SMITH in this timely book.—W.D.R.

LIVESTOCK IMPROVEMENT

J. E. NICHOLS. 4th edn. Oliver & Boyd: Edinburgh, 1957. *xi* + 240 *pp.* (illus.) 16*s*

This well known textbook aims at giving agricultural students, veterinary students and stockbreeders a basic understanding of the principles of livestock improvement. The book enjoys wide popularity as a standard text on the subject, largely due to the fact that the author is at pains to avoid overemphasizing the mathematical treatment of genetics, an approach which often discourages the general biological reader.

The fourth edition of this standard work is disappointing. The author has set about his task of revision mainly by the addition of an extra chapter to the text, labelled ' Review '. This chapter makes difficult reading, and one feels that most of the information contained therein could, with advantage, have been incorporated into the relevant chapters earlier on in the text. The treatment of recent advances in a subject by means of a ' Review ' should be left to the review journals which are designed for this purpose. The practice of adding such articles on to the end of a reasonably elementary textbook has little to commend it.

The author has been let down by his proof readers and several typographical errors appear in the text. For instance BRODY is credited with a paper which he will apparently be writing in 1962! Again on page 6 ' economic size of the herd ' is misprinted as ' economic site of the herd '. On page 7 either a word or a whole phrase has been omitted from the text, with the result that the middle paragraph is meaningless as it stands.

Chapter 7, which deals with ' Environmental aspects ' has entirely missed the point of recent research work in the field of growth and development. Considerable modifications have been made to the earlier theories concerning the magnitude of the effect of plane of nutrition on carcass composition, since the pioneer work of HAMMOND and MCMEEKAN. Recent work on the pre-natal development of lambs and the post-natal development of poultry is not mentioned. Again, far too simple an explanation is provided concerning the genetic control of egg production in poultry. The theories advanced are those reviewed by GREENWOOD in 1935, and the vast amount of more recent research in poultry genetics is not brought into the text.

The book contains a fairly comprehensive bibliography, and the author should be complimented on including the full titles of the papers which he quotes instead of following the normal procedure of merely giving the journal reference. A glance through the bibliography indicates that relatively few of the more recent papers in the field of livestock improvement have been included. Only 46 references are given covering the period from 1950 onwards, whilst 78 references are detailed of work done during the period 1930 to 1940 and 21 references to work done prior to 1930. Whilst the classic papers should continue to hold pride of place in a general textbook of this nature, the reviewer feels that a greater effort might have been made to keep abreast of modern advances since 1950.

In spite of the above criticisms, this book will continue to find its way into the suggested reading lists for agricultural and veterinary students, and remains one of the most readable and most acceptable general texts on the applied aspects of animal breeding.—P.N.W.

INVESTIGATIONS INTO GRAIN STORAGE PROBLEMS IN NYASALAND WITH SPECIAL REFERENCE TO MAIZE (*ZEA MAYS* L.)

K. F. Salmond. Her Majesty's Stationery Office: London, 1957. *ii* + 49 *pp.* (illus.) 4*s* 6*d*

The reports of Oxley (1950)* and Hall (1954)† have drawn attention to the lack of basic data on many aspects of grain storage in East and Central Africa. Miss Salmond's work in Nyasaland has sought to make good these deficiencies especially in regard to stored maize, and this publication gives an account of investigations carried out during the period November 1951 to May 1955. She has surveyed the stored products pests of the territory and assessed their relative importance, and she describes storage methods employed by both Africans and Europeans and discusses the merits of each. Her experimental work has included investigations into storage losses and changes in the moisture content of maize stored in different ways and at different seasons, and assessments of the suitability of underground storage to Nyasaland's climate and of the efficacy of different insecticidal treatments. The methyl bromide fumigation of bagged maize under plastic sheeting has been particularly successful as proved by data showing the reduction in the percentage of damaged grains.

It is to be regretted, however, that the account of such valuable pioneer work should be marred by loose phraseology and the obscure and often uncritical presentation of results. The description of the two-stage moisture determination must surely be incorrect and the author confuses intergranular with atmospheric humidity. Several different measures of insect infestation are given, the most misleading being ' adults per gramme of maize '. Although a comparison between the numbers of different pests is possible on this basis, the idea of the high infestations involved is much less clearly conveyed by ' 6 adults per gramme ' (i.e. per two or three grains of maize) than by the equivalent of 2 724 per lb. In Table 3 (page 19) figures giving

* Oxley, T. A. (1950). *Grain Storage in East and Central Africa.* Her Majesty's Stationery Office: London
† Hall, D. W. (1954). *Report on Food Storage in Nyasaland.* Colonial Office: London

the difference between the original weight of a bag of maize and the weight after 18 months storage enable the reader to calculate that the loss after this period is 19·6 per cent. The value given in the text, however, is 17·6 per cent. This may be a genuine misprint, but the same value is repeated in the summary. Figures V and VI have also been transposed.

This is not to suggest that the results obtained do not support the conclusions, but clearer presentation would have enabled the reader to make an independent assessment of their value.—M.H.B.

A NOTE-BOOK OF TROPICAL AGRICULTURE

Originally compiled by R. Cecil Wood, 6th edition revised and enlarged by the staff of the Imperial College of Tropical Agriculture. Imperial College of Tropical Agriculture: Trinidad, 1957. 256 *pp.* 12*s* 6*d*

This sixth edition has revised and expanded the *Note-Book* which Professor R. Cecil Wood produced in 1933 for ' those interested in the subject '. Professor Wood did not specify who those interested might be; but for students, there is potted information; for those concerned with agricultural research and extension, there is the check on half-remembered formulae; for planters, there is abundant practical information.

The expansion of knowledge on tropical agriculture is reflected in the changes in the chapter headings. The chapter on ' Recipes ' in previous editions becomes three chapters in the sixth edition on ' Insecticides ', ' Fungicides ' and ' Herbicides ' respectively. There are new chapters on ' Soil and water conservation ' and ' Grasses '. The list of ' Current prices ' has gone; so has the list showing the staff establishment of the various Colonial Departments of Agriculture. Instead there is a list of reference books. Some may be a little hurt to see their favourite works omitted from this list but it is difficult to decide just which books to include and the list does not claim to be anything more than a selection.

Useful though this note-book type of information is, it must be related by the user to local conditions. This applies particularly to rations for livestock where availability and cost of local materials must be considered and to labour performances which presumably refer to well supervised gangs under West Indian conditions. The possibility of labourers planting out tomatoes for an eight-hour day at an overall rate of five per minute seems optimistic but I may be wrong.

This is perhaps being too critical. Anyone can go to the *Note-Book* to refresh his memory on the formula for calculating the area of a triangle and on the exact meaning of those groups of capital letters that denote various insecticides and weedkillers. Where else can this information be found all together at the price?—B.J.S.

THE EMPIRE JOURNAL OF EXPERIMENTAL AGRICULTURE

Volume 26, No. 102, April, 1958. Special Anniversary Number, 1933–58. Clarendon Press, Oxford

It is a pleasure, on the occasion of the publication of the Special Anniversary Number of the *Empire Journal of Experimental Agriculture*, to be able to congratulate those responsible for its publication on the success achieved during

the first twenty five years of its existence and to convey best wishes for its future success.

That this *Journal* has served a useful purpose is evident from its wide and increasing circulation. During its earlier years, in particular, it provided a means of disseminating information on a wide range of agricultural subjects from, and to, some of the more remote parts of the world.

The Editorial Board is also to be congratulated on obtaining such a distinguished list of authors for articles in their Jubilee Number. The foreword by the Chairman of the Editorial Board is particularly appropriate for the occasion.

In an age when the word ' Empire ' seems to connote something rather distasteful, it is hoped the present title will be retained as being something associated with proud historical achievement.—W.J.B.

DAIRY CATTLE BREEDING IN THE TROPICS

P. MAHADEVAN. Commonwealth Bureau of Animal Breeding and Genetics: Commonwealth Agricultural Bureaux, Farnham Royal, Bucks. *Technical Communication No. 11*, 1958. *xiii* + 88 *pp.* (illus.) 15*s*

This excellent little monograph is a review of past research work carried out on various aspects of the breeding and management of dairy cattle in the tropics.

The work is not meant as a student's textbook, but rather as a short review of progress made in this important field for the benefit of those actively engaged in animal husbandry work in tropical regions.

As Professor LUSH says in his foreword to this book, the author has rendered a valuable service in assembling and interpreting the diverse papers and reports on dairy production and dairy cattle breeding, and the result is well worth reading even though certain of the author's interpretations may not meet with general approval.

A general criticism of the work is that there are too many short chapters included. Thus the book is divided into sixteen chapters with an average of only five pages devoted to each chapter. Of these five pages one page is devoted to a list of references. The inclusion of these is most valuable but, due to the paucity of papers in the field in question, there is much unnecessary repetition of the major works of reference. Most papers referred to appear in at least five separate reference lists, and the result is unnecessary ' padding ' of an otherwise concise and well written book.

The work does not contain many errors of omission, and in general the information given in each section is remarkably up to date. It is, however, thought that some mention might have been made (possibly in Chapter 4) of the interesting phenomenon, exhibited in many tropical breeds of cattle, of a fall in lactation yield in the second lactation. The point is well made that correction factors for first, second and third lactations have to be calculated afresh for tropical breeds and that the factors at present in use for European breeds are incorrect and inapplicable. However, the fact that many tropical breeds have a depressed yield of milk in their second lactation is neither referred to nor discussed.

In Chapter 10, two pages only are devoted to the all-important topic of

mortality and replacement in tropical dairy herds. Some tables showing the major causes both of mortality and the reasons for dairy replacement might well have been included. Information on this subject exists in the literature, and several papers have been written on the subject by workers at the East African Veterinary Research Organization in Kenya.

The publication is extremely well illustrated with good photographs of representative types of tropical dairy cattle. On the other hand, the work does not contain any reproductions of graphs or diagrams taken from the learned journals, and it is thought that the inclusion of the more important and pertinent of these figures would have added considerably to the overall value of the publication.

The author has, however, rendered a most valuable service to all those interested and involved in the problem of increasing the productivity of tropical livestock, and this publication must be regarded as an essential reference work both in workers' personal libraries and at research institutions. —P.N.W.

THE WEALTH OF INDIA: RAW MATERIALS, VOLUME IV: F–G

Council of Scientific and Industrial Research: New Delhi, 1956. *xxviii* +287+*vii* pp. (illus.)

The first two volumes of this work were reviewed in this Journal, in volume **27,** page 8 and volume **28,** page 34. As was pointed out, it is the successor to Watt's well-known, great six-volume work on the *Economic Products of India*, published 1889–1899. Volume I of the present work was published in 1948, volume II in 1950, volume III in 1952 and Volume IV, here reviewed, in 1956. The present volume which covers the letters F–G maintains the high standard of publication as in previous volumes. It is profusely illustrated with black and white line drawings and photographs and has thirteen coloured plates. Plate 1 is of three fishes, but a small insert informs us that ' The monograph on Fish and Fisheries is being issued as a separate supplement. Every buyer of this volume will get it gratis'.

This volume has about 340 entries, of which 325 are plant species. It includes such varied subjects as fats and oils of animal origin (where we are told that the fat extracted from the crest on the back of a horse's neck is prized in Switzerland as a remedy for baldness), feldspar, flying foxes, *Fragaria chiloensis* (Garden Strawberry), frogs, fullers' earth, fungi, fur and fur-bearing animals, *Gloriosa superba*, gold and *Guaiacum officinale* (Lignum vitae). By far the largest section, of 81 pages, is given to *Gossypium* (Cotton).

The common names of plants are cross-referenced to the scientific names which have already appeared, or which will appear in future volumes. The cross-referencing in itself must have been a formidable task when the work was originally planned. Many works of reference and original publications are quoted and a great deal of literature has been consulted. The standard of the entries varies, as is inevitable when so many contributors are involved.

The Council of Scientific and Industrial Research of the Government of India is to be congratulated on undertaking this considerable work which should be of value to all those who are interested in the world's natural resources.—J.W.P.

THE MANGO

S. R. Gangolly, Ranjit Singh, S. L. Katyal and Daljit Singh. Indian Council of Agricultural Research: New Delhi, 1957. *xiii*+530 *pp.* (illus.) 85*s*

In his foreword to this large book on ' The Mango ', the Minister for Food and Agriculture of the Government of India expresses surprise ' that Europeans in India did not develop sufficient taste for mango ', which they sometimes called the ' bath-room ' fruit, while among Indians it is the most relished and popular of all fruits. The number of mango varieties in India is estimated at over one thousand. Much confusion exists in the nomenclature of the many varieties. As most Indian mangoes are monoembryonic a great many varieties have arisen as the result of cross pollination, as compared with places such as the Philippines where most mangoes are polyembryonic and breed true to type.

The writers of the work under review have endeavoured to standardize the nomenclature of 210 of the more important Indian varieties and they provide a description of each variety, with a brief history of its origin, the seasons of flowering and fruiting, notes on the form of the tree, leaves, inflorescence, fruit, stone and quality, as well as the synonymy where known. There is a coloured plate on each variety occupying a whole page with a description on the opposite side of the page. The plates are rendered somewhat less attractive by ' show-through '.

The title is rather misleading as the work is confined almost entirely to a description of the principal varieties grown in India, and this section takes up 421 pages. The varieties are given in alphabetical order and no attempt is made to provide a key to their classification, so that to identify a given variety it may be necessary to thumb through the 210 coloured plates and then check with the description. On eating the fruit the reader will have to decide whether the flavour is ' mildly pleasant ' or ' delightful ' or some other such category, and whether the taste is ' moderately sweet ', etc. I was somewhat surprised to see no reference to the Julie mango which is so deservedly popular in Trinidad.

There are short introductory chapters on ' Mango in India ' and ' Botany of the Mango ', then follow the description and plates of the 210 varieties. Part 2 of 39 pages describes the ' Cultivation ' and ' Insect pests and diseases '. There is a useful bibliography of 162 references. The book is well printed on glossy paper.—J.W.P.

Recent Publications

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

Memoirs—Economic Series No. 2: Peasant Farming, 1*s*; No. 3: Readings in Small Scale Farming, 5*s*; No. 4: Clip-Card Accounting on the Farm, 8*s* 4*d*

A Notebook of Tropical Agriculture. 6th ed. rev. and enl. 1957. 12*s* 6*d*

THE REGIONAL RESEARCH CENTRE OF THE BRITISH CARIBBEAN

Reports on Cacao Research—1945–51, 25*s*; 1952, 8*s*; 1953, 10*s* 6*d*; 1954, 12*s* 6*d*; 1955–56, 15*s*

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Soil and Land-Use Surveys (with maps)—

No. 1 Jamaica. Parish of St Catherine 1958, 20*s*

No. 2 British Guiana. The Rupununi Savannas 1958, 15*s*

No. 3 St Vincent (in press)

OTHER PUBLICATIONS

Flora of Trinidad and Tobago. (The early parts were edited by the Department of Agriculture of Trinidad and Tobago but editing has now been taken over by the Botany Department of the Imperial College. The Flora may be obtained from either address.)

Volume I—Ranunculaceae to Araliaceae (8 parts and index), 26*s* 6*d*

Volume II—Rubiaceae to Labiatae (6 parts to date), 23*s* 7½*d*
Further parts are in preparation.

These and earlier publications can be obtained from the Library and Publications Department, Imperial College of Tropical Agriculture, Trinidad

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The following book written by a member of the staff has recently been published:

Insect Life in the Tropics, by T. W. KIRKPATRICK. Longmans, Green: London. 35*s*

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QUANTITATIVE PLANT ECOLOGY

By P. GREIG-SMITH, M.A.
University College of North Wales

The growing awareness among ecologists of the need to place their science on a more exact basis is changing the emphasis from extensive work on vegetation to intensive work on selected aspects and, consequently, more precise methods of examination are necessary.

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